Geomorphological Monitoring Protocol:

Part I – Ocean Shoreline Position

Northeast Coastal and Barrier Network

National Park Service

U.S. Department of the Interior

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1.1 Background and Objectives

1.1.1 *Introduction*

As part of the congressionally mandated Natural Resource Challenge, the National Park Service (NPS) has created thirty-two monitoring Networks to ensure the systematic collection and use of scientific data in managing the nations parks (NPS NCBN 2003). The Northeast Coastal and Barrier Network (NCBN) is developing a series of scientific protocols to address a variety of natural resource issues. This document represents the first of several protocols for long-term geomorphological monitoring in the eight parks that comprise the NPS NCBN (Figure 1). Additional protocols will address issues related to coastal topography and estuarine shorelines.

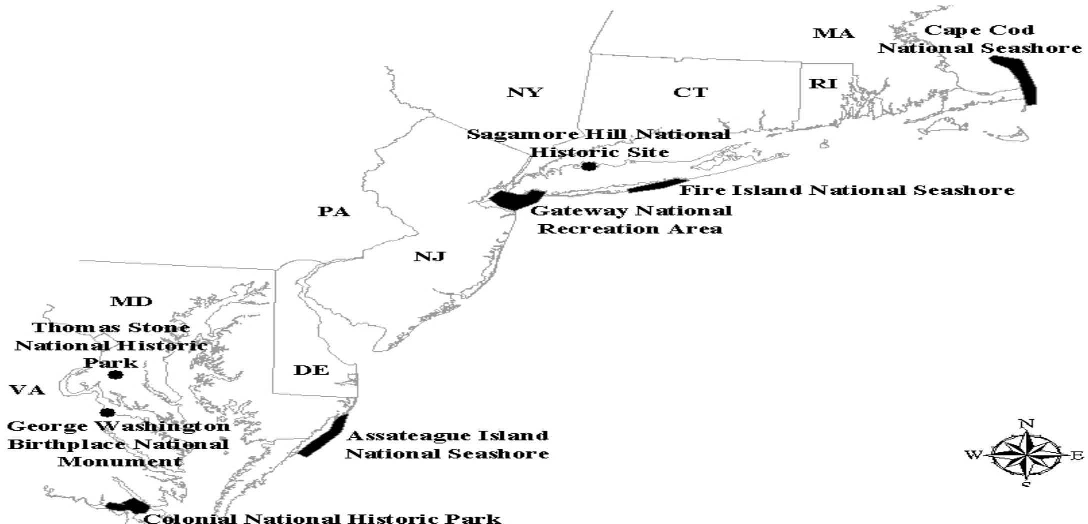

Figure 1. The map shows the locations of the eight NPS units of the Inventory and Monitoring Program, Northeast Coastal and Barrier Network.

The NCBN coastal geomorphology program and its protocols are based upon three underlying principles:

1. All protocols developed by the Network must have a scientific foundation. Collaboration with the scientific community will ensure that all geomorphologic monitoring protocols are based on well-established scientific principles of coastal characterization and response. Because coastal geomorphology is a complex subject, valid interpretation of the data will require the active involvement of knowledgeable coastal scientists.
2. Data must address significant park management issues. Park managers and natural resource staff were active participants in the planning and scoping process in the development phase of the geomorphologic protocols. The objectives identified in this protocol reflect a consensus of issues considered relevant at the park level. The protocol

focuses on recording and assembling the geomorphological dataset to enable better-informed management decisions.

3. All protocols and their components must be feasible to implement at the Network level. Although the scientific and management value of the monitoring data were both critical factors in determining which vital signs or indicators were selected for monitoring, the practicality and feasibility of implementation across the Network were important as well.

Based upon the principles presented above, the Network will be developing a series of protocols to monitor coastal geomorphological indicators or vital signs in ocean and estuarine systems. These indicators occur in both the terrestrial and marine environments and together constitute the overall coastal geomorphological envelope of concern for the Network parks. Protocol development is based upon the balance between the need to collect and analyze datasets that will lead to better understanding of the complex processes associated with geomorphological change, and the practical considerations of conducting monitoring in the Network parks over the long-term. Changes in shoreline position in the Network parks were identified by coastal scientists and park managers as geomorphologically significant, and the data can easily be assembled and quickly and effectively incorporated into park management operations. Based on these and the following factors, ocean shoreline position was selected as the first of the geomorphological monitoring protocols to be developed and implemented by the Network:

- Changes in shoreline position serve as a surrogate for sediment budget measurements.
- Changes in shoreline position document the seasonal, annual, and long-term trends in beach displacement.
- Shoreline position is compatible with the historical record and ongoing collection.
- Shoreline position monitoring is feasible to implement at the Network level.
- Shoreline position data is readily used at the park level in various management applications.

The ocean shoreline position protocol includes a number of highly detailed standard operating procedures (SOP). They are intended to ensure the consistency and repeatability essential to any long-term monitoring program. These SOPs will be modified and revised as technology improves and better methods for monitoring coastal geomorphologic change are developed.

1.1.2 ***The Ocean Beach-Dune Ecosystem***

The ocean beach-dune ecosystem occupies an area that extends from the nearshore aquatic environment landward across the intertidal zone, sub-aerial beach and berm, and through the primary dune. In the Network parks, there are a variety of landforms that incorporate nearshore bars, inlet channels and deltas, fully developed beaches, foredunes and dune fields, cliffs, and bluffs. This ecosystem is an area of active cross-shore and alongshore sediment transport. There are manifestations of areas of sediment accumulation (deposition), such as foredunes and dune fields and inlet deltas, as well as features related to erosion, such as scarps, cliffs, and bluffs. The beach-dune system interacts with wind, waves, and currents on a variety time scales, including individual storms, seasonal periodicities, and longer-term changes. The result is a sand-sharing system that is extremely dynamic, variable, and complex.

The landscape of the beach-dune ecosystem is characterized by a continually evolving morphology and its habitat is extreme, marked by highly variable temperatures, salinities, moisture levels, and an episodic nutrient flux. Often considered an area of limited biodiversity, the beach-dune ecosystem provides habitat for numerous pioneer, resident, and migratory species. The aquatic and inter-tidal zone includes plankton, various vertebrates and invertebrates, crustaceans, mollusks, and polycheate worms. High densities of these organisms provide food for migrating shorebirds that depend on this source of nourishment to support inter-continental migration and the feeding of fledglings. Other plant and animal species use the sandy substrate of the upper beach and berm for breeding, nesting, and propagation. The ocean beach-dune ecosystem in the Network's ocean parks includes habitat for several federal and state listed species.

The basis for the ocean shoreline protocol is the beach-dune conceptual model (Roman and Barret 1999) which relates the physical and cultural processes (agents of change) to the vectors of change (stressors) and to the responses of the coastal ecosystem (Figure 2). Fundamental to the model is an awareness that the coastal system is dynamic and that it is interacting at a variety of geographical and temporal scales. The model consists of an assemblage of natural and cultural agents and processes that generate characteristics of the coastal landscape. As the relative magnitude of the agents and processes vary, they cause alterations to the hydrology and sediment budget and consequently to the landscape. Furthermore, there is a continuous interaction and feedback amongst the evolving components that drive additional changes and alterations. A primary manifestation of the alteration is a shift in shoreline position and modification of the beach-dune topography. These coastal geomorphological changes result in a continuous ecosystem response that incorporates changes in the physical environment and in the community structure and function (Figure 2).

The primary natural disturbances that drive geomorphological change are sea-level rise, sediment supply, and wave climate. These natural factors influence coastal geomorphological response at different temporal scales including individual events (storms), cyclic variations (seasonal), and annual and multi-year (long-term) trends (Carter 1988, Psuty and Ofiara 2002). One of the effects of the long-term trend of sea-level rise is inland displacement of the shoreline. When coupled with erosion produced by a prevailing sediment deficit, the rate of inland shoreline displacement is increased (National Research Council 1987; Warrick 1993). Whereas sea-level rise and sediment supply are the primary natural agents of change, wave climate is the principal agent that steers the local sediment transport and consequently controls the site-specific shoreline configuration (Trenhaile 1997).

Local conditions such as the underlying geologic framework, bathymetry, offshore topography, and sediment sources and sinks interact with the primary agents of change to influence the characteristics and the rates and direction of the coastal system alterations (Honeycutt and Krantz 2003). In addition to natural causes, coastal changes are often accelerated by human perturbations such as dredging and channel relocation, groins and jetties, and beach and dune manipulation (Nordstrom 2000). These human influences can cause alterations to waves, currents, and availability and mobility of sediment. The combinations of natural and anthropogenic processes interact to cause significant morphological change that leads to ecosystem response.

Coastal ecosystem response may consist of adjustments to resource patterns and dynamics, and may eventually lead to the loss of fixed natural resources (Roman and Nordstrom 1988). These responses often elicit secondary changes in ecosystem structure or function. Structural changes in species composition or competitive interactions generally reflect landscape-level alterations in the quantity and quality of specific habitats. Similarly, functional changes in productivity or nutrient cycling may occur as a product of storm events and the associated reduction in habitat complexity. More subtle physical changes also include alterations in geo-chemical and hydrologic conditions, such as groundwater quality and quantity. The magnitude and scope of the resultant coastal ecosystem response is complex, highly variable, and can often be cumulative. At the extreme, this includes the alteration of habitats and of core ecosystem processes. For example, erosion of an existing shoreline may create new aquatic habitat, or overwash fans may fill in a wetland environment to create new terrestrial habitat.

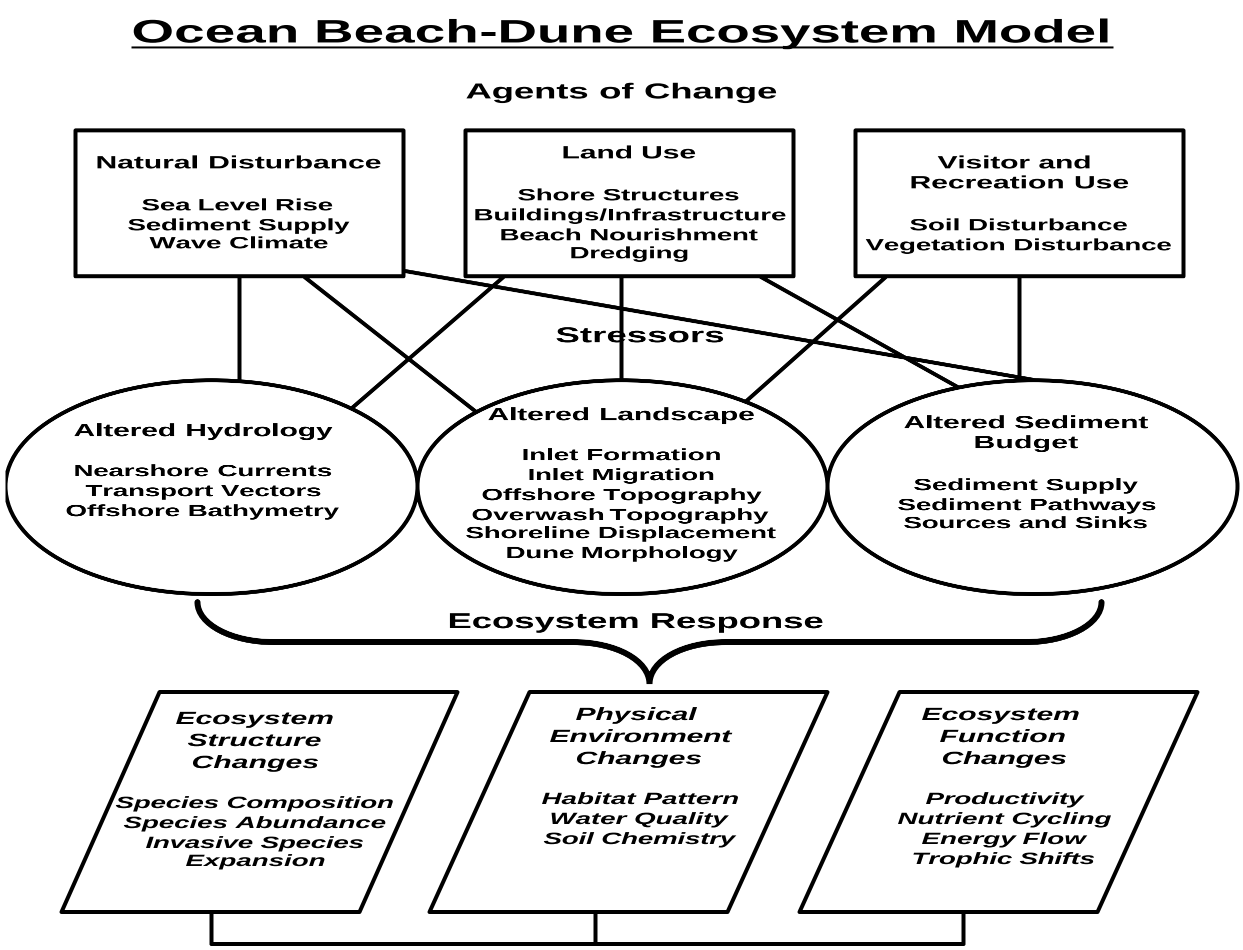

Figure 2. The Ocean Beach-Dune Ecosystem Model illustrates the relationships amongst the agents of change, stressors, and ecosystem response. (Roman and Barrett 1999)

1.1.3 *Process of Evaluating Vital Signs*

Geomorphological change is important to the evolution of the coastal ecosystem. and in some cases, when it affects natural and cultural resources, recreational features, and facilities or infrastructure, presents complex challenges to park management. In order to address the full range of scientific and management concerns, multiple scoping workshops were convened to identify issues of general importance and to make specific recommendations for monitoring. Throughout the scoping process, the lack of adequate data to track and respond to geomorphologic change was consistently identified as a high priority management issue. Demonstrating the complexity of the coastal geomorphologic process, twenty-nine potential monitoring variables (vital signs) of geomorphologic change were identified by the workshops (NPS NCBN 2003). Following the workshop, the number was reduced by combining similar indicators and eliminating redundant items. The remaining fourteen vital signs were evaluated and ranked for data value and feasibility of implementation at the Network level (Table 1).

Vital Sign	Measurement	Monitoring Methods	Feasibility	Data Value
Shoreline Position	Shoreline position	2D GPS, 3D Survey, Aerial Photography, LIDAR	high	high
Coastal Topography	Dune, beach, cliff, bluff morphology	LIDAR, Aerial Photography, 3D Survey	high	high
Coastal Topography	Edge of vegetation	LIDAR, 2D GPS, Aerial Photography	high	high
Coastal Topography	Landcover	LIDAR, 3D Survey	high	high
Coastal Topography	Overwash fans/flood plains	LIDAR, 2D GPS, 3D Survey, Aerial Photography	medium	high
Coastal Topography	Shore type	Aerial Photography, 2D GPS, 3D Survey	medium	medium
Anthropogenic Modifications	Locations of structures and disturbances	Aerial Photography, 2D GPS, 3D Survey	medium	high
Marine Geomorphology	Sediment quantity Sediment size	Terrestrial and Marine Sediment Samples	medium	medium
Marine Geomorphology	Geologic framework	Acoustic Survey, Seismic Survey, Core Samples	low	high
Marine Geomorphology	Depths	Acoustic Survey, Bathymetric LIDAR, Sled survey	low	medium
Marine Geomorphology	Migrating shoals & bodies	Acoustic Survey, Bathymetric LIDAR	low	high
Marine Hydrography	Tide range	Local & Regional Tide Gauge	high	high
Marine Hydrography	Relative sea level position	Water Level Gauge	high	high
Marine Hydrography	Wave and current characteristics	Local Gauge -Regional Gauge	low	high

Table 1. The fourteen Vital Signs identified during the Northeast Coastal and Barrier Network Geomorphologic Change Workshops, evaluated and ranked for data value and feasibility of implementation at the Network level.

1.1.4 *Monitoring Coastal Shoreline Position*

Detailed knowledge of the hydrodynamic forcing of sediment mobilization, transport, deposition, and measurements of morphologic change and ecosystem response at the park level is key to understanding the coastal geomorphology of NCBN parks (Allen 2000). Although a number of these geomorphologic change indicators are difficult to measure, there are several, such as shoreline position, that have high value (Table 1), can be measured effectively, and can be used to address park management issues. Further, because shoreline position monitoring can be most easily implemented at the Network level, it was selected as the first of several protocols to be developed.

From a scientific perspective, shoreline position represents the morphological response of wave and current processes acting upon sediment supply (Komar 1998; Short 1999). Understanding the dynamics of changes in shoreline position over time, through standardized data collection, will provide a scientific basis for informed resource management (National Research Council 1995). Additionally, historical shoreline positions data exist for many of the NCBN parks, thereby providing the opportunity for long-term comparison. The assemblage of reliable and consistent data enables robust statistical analysis, yielding a better understanding of episodes, cycles, and trends (Colwell and Thom 1994; Dolan and Hayden 1983). The result is a program that leads to improved knowledge of the results of coastal processes.

Shoreline monitoring provides knowledge of the spatial and temporal variation in sediment transfers and sediment budget and creates a fundamental database for use in park management. Collecting a record of the changes in the shoreline position over time chronicles variation in sediment supply and distribution (Allen, et. al., 1995). The collection of the shoreline position twice a year, in the early spring (the fully developed winter beach) and the early fall (the fully developed summer beach), leads to the accumulation of a time series of seasonal shoreline positions that represent the annual theoretical maximum and minimum configurations of the beach. Each annual pair of shorelines portrays the magnitude of variation created by the changes in the seasonal wave climate acting on the beach sediment supply. Longer term comparisons of shoreline positions reveal changes created by differences in sediment availability and intensity of formational processes. In addition, there are aspects of shoreline variability, such as geotemporal trends and cycles, that can only be revealed by long term data collection.

The objective of the NCBN shoreline position monitoring protocol is to identify the seasonal, annual, and long-term trends and variability of shoreline position in the Network parks. Meeting this objective will address the following questions:

- ***What is the displacement of the shoreline?***
- ***What are the seasonal dimensions of the displacement?***
- ***What are the annual dimensions of the displacement?***
- ***What are the long-term dimensions of the displacement?***
- ***What are the spatial and temporal trends in the shoreline displacement?***

Accomplishing the objective of this protocol requires the following steps: 1) standardization of the survey methodology, 2) design and construction of the database, 3) reporting of the assembled data and, 4) scientific analysis and interpretation.

1.1.5 *Historical Development of Methods used for Monitoring Shoreline Position*

Coastal mapping and the measuring of coastal features have utilized an evolving suite of data collection methods. Early techniques in the United States involved the Coast & Geodetic Survey conducting surveys of the coast beginning in the early 1800s. This method was extremely labor intensive and the long time periods required to complete a survey proved to be problematic in capturing anything resembling an instantaneous shoreline position. However, these early efforts did result in systematically collected datasets that were suitable for general delineation and comparison of coastal features, and they established general baselines in many coastal areas (Graham 2003).

The development of aerial photography in the early twentieth century created the opportunity for rapid data collection and the extraction of multiple features from the images (Moore 2000). Comparison studies between ground surveys and aerial photography showed a general level of compatibility between the data (Krauss 1997). The ability to capture large geographic areas of the coast continues with space based satellites. Satellite technology is becoming a viable option for many coastal data acquisition purposes. Currently there are multiple studies within the NCBN to assess the utility of satellite imagery for coastal mapping.

The last twenty years have seen a revolution in mapping sciences in general and coastal mapping sciences in particular. The development of Geographic Information Systems (GIS) allows the simultaneous display, manipulation, and analysis of multiple datasets. In the 1980s and 1990s, GIS technology was augmented by the addition of satellite based Global Positioning Systems (GPS), creating the opportunity for more efficient, frequent, and precise measures of geomorphologic features. Together these technologies greatly increased the capacity for updating, analyzing, and reporting changes in coastal conditions.

The revolution in coastal mapping continued into the 1990s when LIDAR (LIght Detection And Ranging) technology was applied to the coastal zone (Krabill 2000). The airborne laser mapping system can deliver high-resolution measurements of the entire non-vegetated beach and dune system and use the three-dimensional data to extract a variety of coastal features, including shoreline position. LIDAR technology has evolved rapidly and systems now exist that can penetrate sparse to moderate vegetation (Wright and Brock 2002) and some shallow waters to provide detailed topography and bathymetry over large segments of coastal systems.

NPS geomorphological monitoring has generally mirrored the developments in the coastal sciences (Allen and LaBash 1997). In some cases, the NPS has played a major role in the development of modern, technology-based data acquisition efforts (Brock 2001). Network parks were early users of GPS shoreline surveys and a park focused NASA research experiment in the mid-1990s was one of the earliest cases of LIDAR technology applied to beach mapping.

Currently, there are a variety of independent data collection activities underway in individual NCBN parks. At present, none of these efforts meets the rigorous data collection and data management standards established by the service-wide inventory and monitoring program. However, many of the concepts, methods, and techniques used in individual park programs are applicable to Network-wide long-term monitoring. By providing a consistent and systematic framework for collection, analysis, and reporting, the NCBN will utilize this collective knowledge and experience from existing park programs to build a long-term, Network monitoring program.

1.2 Sampling Design

1.2.1 *Selecting the Shoreline Feature and Measurement*

The shoreline represents the intersection between water and land surfaces. The location of the intercept on the beach profile (Figure 3) varies due to the effects of tides, waves, and atmospheric conditions. Shorelines may be delineated based on a datum intercept, or identification of some morphological feature, or some visual characteristic. Multiple conventions and terms are used to describe the various positions of the intercept. Datum shorelines such as Mean High Water (MHW) are quantitative and use a calculated identification of an exact elevation to extract the intercept. (Parker 2003; Pajak and Leatherman 2002). On the other hand, morphologic features such as berm crest or cliff base or visual features such as the high water mark, high-tide swash line, or water's edge are typically qualitative and based on a visual interpretation. Any of these may be used to represent a shoreline position under specific circumstances.

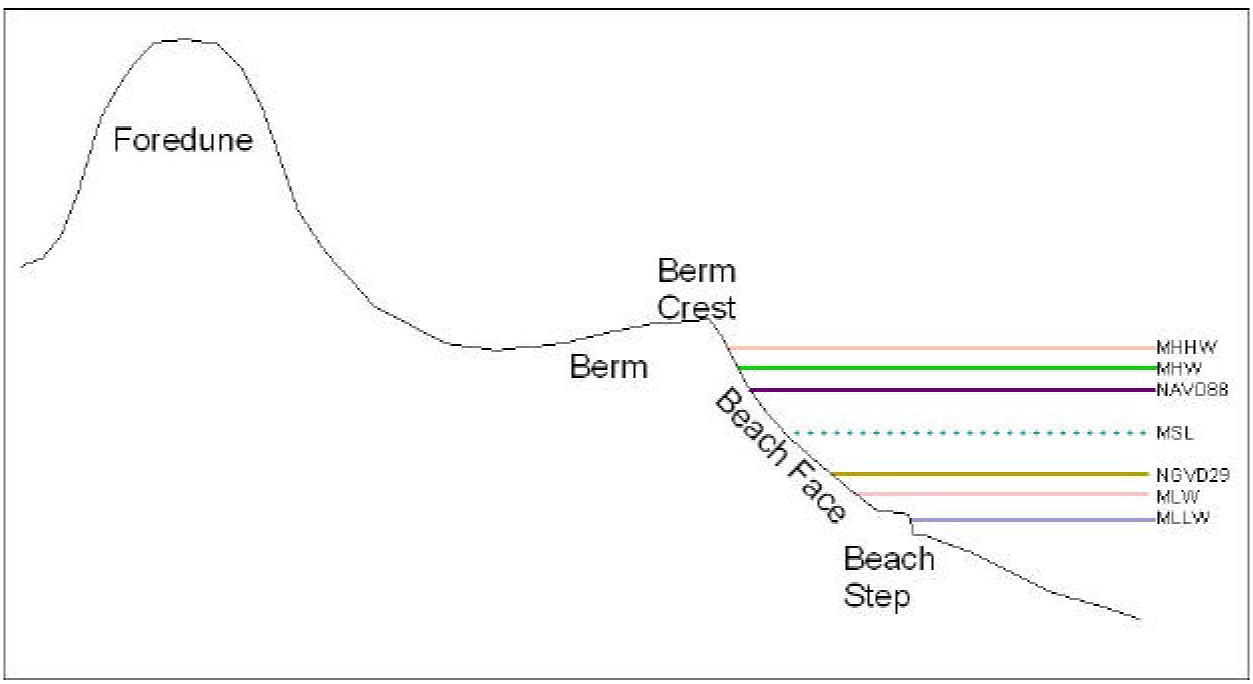

Figure 3. This figure shows the relationship of the various physical features and vertical data (datum) to the beach profile.

Datum-based derivations are precise measures of shoreline position based on a specific vertical elevation. However, Network-wide data collection necessary to extract this feature at the geotemporal scale required to identify seasonal and episodic variability is currently impractical because of resource limitations, lack of suitable equipment, and the absence of a tested methodology for regular and broad geographic data collection

On the other hand, qualitative shorelines are less precise but their derivation is feasible for use in a long-term, Network-wide monitoring program (Pajak and Leatherman 2002). Among the qualitative features described above, the neap high-tide swash line is consistently available, readily identified, and easily collected; and thus it is selected as the indicator of shoreline position in this protocol (Figure 4). In the context of the NPS Network based monitoring program, a systematically planned and executed survey utilizing the high-tide swash line as shoreline position is well suited to the needs, resources, and capabilities of the program.

Properly planned and executed GPS surveys can provide sufficient data to monitor the long-term trends and variability in shoreline position. Due to the shoreline's alongshore spatial variability, determining these trends requires both high resolution and high frequency data along its entire length (Allen 1995). Further, the timing of the survey can be adjusted for local tides and weather conditions, making GPS surveys comparable and more convenient than many other established methods of shoreline mapping.

Figure 4 – The high-tide swash line (red dashed line) on the beach face.

1.2.2 *Geographical Extent of the Surveys*

In order to determine alongshore variability, the survey will encompass the entire length of the ocean beach at each of the Network's ocean parks (ASIS, CACO, FIIS, and GATE). The spatial extent includes the entire ocean shoreline, and the inlet shoreline from the oceanside to a transition area characterized by a distinct orientation change and a reduction of wave and current energies. Park specific descriptions and maps/diagrams of the survey area are included in SOP #3 – Site Location and Geographical Extent.

1.2.3 *Survey Frequency and Timing*

Weather induced changes in wave climate produce a distinct seasonal response in the shoreline position (List and Farris 1999). These features typically reach their peak expression around the end of the winter and summer seasons. In order to track this seasonal variation, shoreline surveys will be conducted on a twice per year basis and timed to capture the general occurrence of the maximum seasonal (winter/summer) state. The winter shoreline position will be collected in mid-March to late April and the summer shoreline position in mid-September to late October. Attention should be given to local weather conditions so as not to perform the seasonal survey within one week of a storm event (SOP#4 - Survey Timing and GPS Mission Planning).

The shoreline survey should also be conducted when minimum satellite availability and satellite geometry specifications are met. Four satellites with a maximum position dilution of precision (PDOP) equal to or less than six are the minimum recommended specifications for the survey (SOP#6 – Conducting the Shoreline Survey). In addition there may be park specific issues such as the presence of species of concern or public activities that constrain the conducting of the shoreline survey. Park management should always be consulted in advance when planning the survey. Details for timing and mission planning are provided in SOP #4 – Survey Timing and GPS Mission Planning

As stated above, storm influenced beaches should be avoided when conducting the seasonal shoreline survey (Morton and Sallenger 2003). However, storm response shorelines provide important measures of short-term variation and can be of great value to both park managers and coastal scientists. Pre-and-post-storm shoreline position surveys should be considered whenever possible. Because numerous storms of varying intensity and duration are expected to affect a given park in a typical year, the decision of when to conduct these additional surveys is problematic. At this time, there is no quantifiable measure or formula to calculate what constitutes a storm event. Local observation and judgment must be exercised in making the determination whether or not to conduct the supplemental surveys.

1.3 <u>Field Methods</u>

1.3.1 *Field Season Preparations and Mission Planning*

Prior to the survey window, the entire protocol should be reviewed by the NCBN geomorphologic monitoring project manager, the designated field observer at each park, and any park or Network staff or cooperators who will collect, process, or otherwise handle the shoreline data. Immediately following the protocol review, Internet URLs should be checked and mission planning for tides and satellite availability and satellite geometry should be initiated (SOP#4 - Survey Timing and GPS Mission Planning). Field equipment should be checked (SOP#1 – Equipment Needs). Two of the determining factors for the timing of the survey are tide and satellite availability. Both tide and satellite availability should be analyzed and a list of potential survey dates and times established and prioritized (SOP#4 - Survey Timing and GPS Mission Planning). As the survey window approaches, extended weather forecasts should be obtained and analyzed so that storm conditions can be avoided (SOP#4 - Survey Timing and GPS Mission Planning). It is strongly recommended that a trial survey be conducted to familiarize the surveyor with the visual expression of the high tide swash line. A limited pre-survey test run is sufficient.

1.3.2 *Conducting the GPS Shoreline Survey*

The survey is designed to capture as closely as possible the position of the high-tide swash line (Figure 5). Surveys along the ocean shoreline are accomplished by driving a four-wheel all terrain vehicle (ATV) or four-wheel-drive truck at a relatively constant speed (approximately 10 mph) along the high tide swash line. For the purposes of this monitoring program, the target ocean shoreline is represented as the position of the most recent and highest swash line (SOP#6 – Conducting the GPS Shoreline Survey). The GPS receiver is configured to record positions at a very short interval (typically one position per second or roughly every 5 meters) for the best representation of the shoreline position (SOP#5 - Basic GPS Settings for Position Collection). The ATV should be driven so that the position of the antenna is located over the swash line. At least two survey monuments or some other marker with known coordinates should be included in the survey for general accuracy assessment. Additional details are included in SOP #6 - Conducting the GPS Shoreline Survey.

Figure 5 – The high-tide swash line is clearly identified as a wet/dry line with wrack.

1.3.3 *Post-survey Data Download and Initial QA/QC*

Immediately upon completion of the survey and return to the office, the GPS data file will be downloaded from the receiver to a computer hard-drive and a backup copy created (SOP#7 – Initial Post-Survey Processing). The data should be retained on the data logger until quality checks can be made. The downloaded data should be visually checked for general spatial integrity and the file attributes reviewed for field notations. The Field Data Form (FDF) should be completed and reviewed.

1.4 Data Management

Placeholder: To be inserted by NPS NCBN.

1.5 Data Analysis and Reporting

Placeholder: To be inserted by NPS NCBN.

1.6 Personnel Requirements and Training

1.6.1 *Roles and Responsibilities*

The NCBN is responsible for the development and implementation of the protocol and has assigned a Network staff-person as project manager. The project manager is responsible for coordinating protocol development as well as an implementation plan and schedule that is suited to the needs of the individual Network parks. The project manager will work closely with Network parks and their designated cooperators to develop and implement this protocol.

The shoreline position protocol is designed to utilize local staff for field data collection. The data collection is improved through the use of personnel who have a basic understanding and working knowledge of the park and its resources. Because of their familiarity with its appearance, local personnel are much better situated to perform periodic observations of the beach. Their participation will thus greatly enhance accurate and consistent identification of the shoreline feature. The use of local staff also limits or prevents the problem of schedule overlap - where Network staff and cooperators might be expected to work in multiple parks at or around the same time frame.

Inconsistencies inherent to qualitative (visual) identification of the shoreline are reduced when the number of observers is limited. Because it is a qualitative feature, no two observers will see or drive exactly the same shoreline. Spatial variability due to observer interpretation must be recognized and acknowledged. However, because an objective of the protocol is the establishment of long-term trends, it is likely that the minor inconsistencies introduced through the use of multiple observers will not seriously affect the value of the data. Nonetheless, consistent feature identification and measurement is important and assignment of data collection to a single or small number of Network-trained observers is highly recommended.

The data management aspect of the monitoring effort is the shared responsibility of the field surveyor, the park and Network data managers, and the Network project manager. The field surveyor is responsible for field data collection, initial data download, and initial QA/QC. The field surveyor should work closely with the Network and/or park GIS specialist for additional post-processing, differential correction, data verification and data validation, preliminary data editing, and export to the designated GIS format. The Network project manager is responsible for data documentation (metadata), data summary, and basic analysis and reporting. Ultimately, the NCBN geomorphologic monitoring project manager has the responsibility to see that adequate QA/QC procedures are built into the database management system and that appropriate data handling procedures are followed.

To address data access and use issues, the Network is developing and packaging a suite of GIS tools to perform basic analysis and visualization of geomorphologic data (Rodriguez 2004). However, analysis with the GIS toolbox does not eliminate the need for professional analysis of the shoreline data by a coastal scientist with knowledge of the relevant issues, resource, and processes.

1.6.2 *Qualifications and Training*

An essential component in the collection of shoreline data is a knowledgeable, competent, and attentive field surveyor. Because visual interpretation of the shoreline is the essential element of the protocol, the ability of the field surveyor to consistently identify the target feature is critical to accurate data collection. The field surveyor should have a basic understanding of coastal and shoreline processes, familiarity with the resource and appearance of the shoreline expression on the local beach, and competence and experience in the operation of all equipment being used in the survey. The NCBN will assess the situation in each park and train local staff as required. (SOP #2 - Training for Field Data Collection).

1.7 <u>Operational Requirements</u>

1.7.1 *Annual Workload and Field Schedule*

GPS surveys will be conducted in early spring (mid March to late April) and early fall (mid September to late October), a period that coincides with the peak expression of seasonal beach variability in the NCBN ocean parks. Extreme tide and weather events will preclude the scheduling of surveys to specific annual dates. Shoreline surveys require one person although the survey could benefit from the use of one or more additional staff if qualified persons and the necessary equipment are available. Due to the different lengths of ocean shoreline in Network parks, time required for data collection will vary. In general, approximately five days should be allocated to complete all requirements of the field survey.

1.7.2 *Facility and Equipment Needs*

The equipment needed for the field survey consists of a four-wheel-drive vehicle (ATV is recommended), appropriate safety gear such as helmet, goggles, and gloves, and a GPS unit capable of sub-meter accuracy, single point position collection, and post-processed differential correction (e.g. Trimble ProXR or equivalent). If two or more surveyors work simultaneously, field equipment requirements will increase accordingly. Should a park lack the proper equipment, the Network will attempt to arrange access to the items necessary to conduct the survey.

A computer and peripheral devices with appropriate ports and cables, GPS processing software (Trimble Pathfinder Office) for download, initial QA/QC, and export to ESRI GIS format are required to complete the initial tasks. The GIS component consists of the ESRI ArcGIS software. Regardless of the number of field surveyors deployed, office computing needs remain as stated above. Specifics for equipment needs are detailed in SOP #1 – Equipment Needs.

1.7.3 *Startup Costs and Budget*

Startup costs consist of the ATV, the GPS unit, and if the survey is planned and executed locally, the surveyor's time (Table 2). If NCBN staff or their partners are required to perform the survey, staff time plus travel expenses must be included in the costs. Equipment consists of a GPS unit, an ATV, and a computer running GPS and ESRI GIS software. All of these items are available at Network parks. Gasoline for survey vehicle, media for backup of data, and other such costs are considered minimal and incidental.

Item/Activity	1st Year Cost	5 Year Total Cost	Annual Cost	Annual Cost per Park	Per Survey Cost
ATVs (4)[1]	26000	26000	5200	1300	650
GPS (4)[2]	40000	40000	8000	2000	1000
Personnel[3]	12000	60000	12000	3000	1500
Computer[4] with ESRI GIS	12000	18400	3680	920	460
Total	90000	144400	28880	7220	3610

Table 2 – Data Collection Cost Estimates.
1= 1 ATV for each ocean park
2= 1 GPS per ocean park
3= Based on 8 weeks (2 weeks per park) at GS9
4= 1 Computer and 1 annual ESRI GIS license per ocean park

1.8 Procedure for Revising and Archiving Previous Versions of the Protocol

Over time, revisions to both the Protocol Narrative and to specific Standard Operating Procedures (SOPs) are to be expected. Complete documentation of changes to the protocol, and a library of previous protocol versions are essential for maintaining consistency in data collection and for appropriate treatment of the data during data summary and analysis. The MS Access database for each monitoring component contains a field that identifies which version of the protocol was being used when the data were collected. The rationale for including a narrative with supporting SOPs is based on the following:

- The Protocol Narrative is a general overview of the protocol that gives the history and justification for doing the work and an overview of the sampling methods, but that does not provide all of the procedural details. The Protocol Narrative will only be revised if major changes are made to the protocol.
- The SOPs, in contrast, are very specific step-by-step instructions for performing a given task. They are expected to be revised more frequently than the Protocol Narrative.
- When a SOP is revised, in most cases, it is not necessary to revise the Protocol Narrative to reflect the specific changes made to the SOP.
- All versions of the Protocol Narrative and SOPs will be archived in a Protocol Library.

The steps for changing the protocol (either the Protocol Narrative or the SOPs) are outlined in the "Revising the Protocol SOP". Each SOP contains a Revision History Log that should be filled out each time a SOP is revised to explain why the change was made, and to assign a new Version Number to the revised SOP. The new version of the SOP and/or Protocol Narrative should then be archived in the Long Term Ecological Monitoring Protocol Library.

1.9 References

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Geomorphological Monitoring Protocol for the Northeast Coastal and Barrier Network

Standard Operating Procedure (SOP) # 1

Equipment Needs

Version 1.0 (June 2005)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This standard operating procedure (SOP) details the items needed to execute the ocean shoreline position protocol. The ocean shoreline protocol requires three major groups of equipment, a field data form, and a field item checklist. The equipment groups are:

1. A single-point differentially-correctable sub-meter GPS system to survey the shoreline positions.
2. A means of transportation and a mounting device to carry the GPS during the survey.
3. A PC for communication with the datalogger and for pre- and post-survey activities such as mission planning and data processing.

GPS System

Any GPS system may be used that has sub-meter precision and is capable of post-processed differential correction on each point. Operational settings and parts for each of the GPS systems may be different, but there are critical settings (SOP#5) and components that allow for consistent data collection across platforms. The Trimble ProXR is the example GPS used for this SOP because it meets the specifications for shoreline data collection and because it is readily available throughout the Network.

Critical Components for the GPS System:

The minimum GPS components necessary to complete the ocean shoreline position protocol are:

1. 12-channel receiver
2. Datalogger (internal or external)
3. Antenna (internal or external)

4. Batteries and Chargers
5. Cables (as needed)

Trimble ProXR Example:

1. 12-channel ProXR Receiver (main unit) part number (P/N) 46090-11
2. Datalogger – (several options available, recommend TSC1 P/N 29673-50)
3. Integrated GPS/Beacon Antenna with Extension Poles P/N 29563-00
4. Camcorder Batteries P/N 17466 and Charger
5. Antenna to Receiver Cable P/N 22628
6. Receiver to Datalogger Cables P/N 30231-00, 24333, 45052

Transportation Requirements:

1. 4x4 vehicle with GPS mount or
2. Quad or All Terrain Vehicle (ATV) with GPS mount (Figure 1)

Mounting Requirements for Walking:

1. Backpack (Figure 2) or
2. Lumbar Pack (Figure 3)

Emergency and Safety Supplies:

1. Shovels (4x4 only)
2. Wooden Boards (4x4)
3. Extra Fuel
4. Cell Phone or Radio

Figure 1. Example of GPS mount for the Trimble ProXR on a quad/ATV. (Photo – ASIS GIS lab).

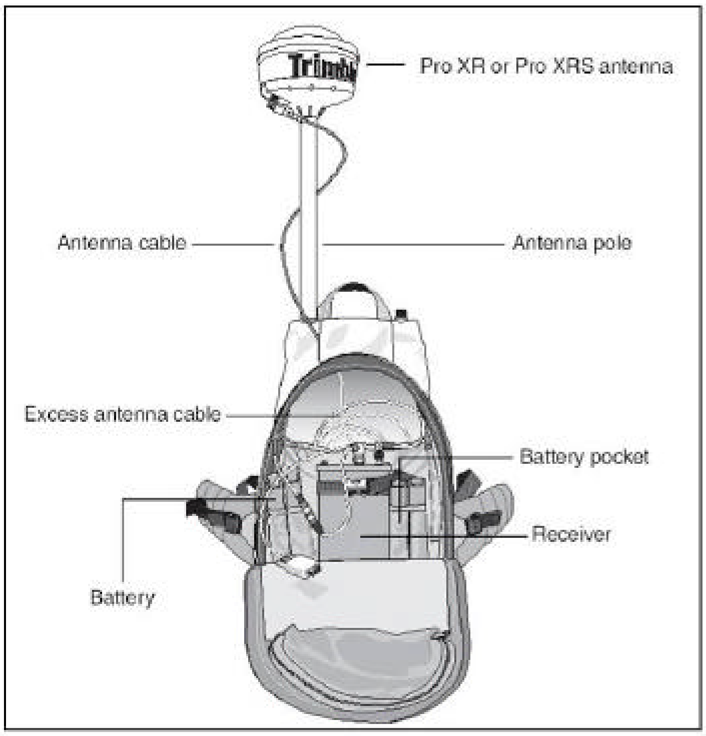

Figure 2. Example of Backpack mount for Trimble ProXR. (source: Trimble ProXR manual; page 52; April, 2004).

Figure 3. Example of lumbar mount for Trimble ProXR. (source: ASIS GIS lab).

Office Computer Equipment

A PC that meets the minimum specifications for running Trimble Pathfinder Office software is required. The NPS minimum standard for computer equipment meets these requirements.

Hardware Specifications:

1. Pentium 400 MHz microprocessor
2. 64 MB RAM
3. 400 MB disk drive storage space (for software installation and data file storage)
4. CD or DVD reader/writer for hard copy data backup (SOP#7 –Initial Post-Survey Processing)
5. Port and Cable for connection to the datalogger

Operating System:

Microsoft Windows 95, 98, Me, NT 4.0 (service pack 4 or later), 2000, XP, or XP Tablet PC edition.

Internet Connectivity:

An internet connection (28.8kbps modem or faster) is needed for viewing the satellite almanac and tide charts (SOP #4), conducting part of the differential correction (SOP #7), and maintaining the GPS software/firmware updates.

Form and Checklist

In addition to the GPS equipment and transportation items, there are four items that are used in the preparation and execution of the protocol.

1. Ocean shoreline position protocol narrative and SOP package.
2. Field copy of SOP#6 - Conducting the GPS Shoreline Survey
3. Field copy of the Field Data Form (Form #SOP6-1)
4. Office copy of the Field Equipment Checklist (Form #SOP1-1) – Items listed on the Field Equipment Checklist are in three categories. Each of items in these categories are classified as items that will always be used **(required),** items that may be used or that are used in case of emergency **(recommended),** and items that are auxiliary **(optional)**.

Form #SOP1-1

FIELD ITEM CHECKLIST

1. GPS Equipment

- ? Data logger (required)
- ? Antenna (required)
- ? Extension poles (recommended)
- ? GPS receiver (required)
- ? Internal datalogger batteries – fully charged (required)
- ? Backup batteries – fully charged (required)
- ? Antenna cable (antenna to receiver) (required)
- ? Antenna cable adapter (antenna end) (required)
- ? Battery cable (required)
- ? Receiver to datalogger cable (required)

2. Transportation Equipment

- ? Quad or 4x4 (required unless walking entire survey)
  - ? Backpack/lumbar pack (required)
- ? Antenna mount (required)
- ? Boards/rope or tow cable/shovel (4x4) (recommended)
- ? Sufficient fuel (required)
- ? Extra fuel can (recommended)
- ? Tire pressure gauge (recommended)

3. Auxiliary Items

  - ? Cell phone or Radio with charged battery (required)
  - ? Field copy of SOP#6 – Conducting the GPS Shoreline Survey (required)
- ? Field copy of Field Data Form (required)
- ? Map of benchmarks (recommended)
- ? Benchmark datasheets (optional)
- ? GPS receiver manual (optional)
- ? Satellite availability and PDOP information (optional)
- ? List of emergency phone numbers (required)
- ? List of contact numbers (required)

Geomorphological Monitoring Protocol
for the
Northeast Coastal and Barrier Network

Standard Operating Procedure (SOP) # 2

Training for Field Data Collection

Version 1.0 (June 2005)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This SOP establishes the responsibility for conducting training, details the content and frequency of Network training, and identifies the target audience of training. Because there are a number of decision-making steps in the protocol there is a need to provide for an understanding of coastal processes as a foundation for making shoreline identification. Training also explains and demonstrates the procedures for mission planning, operation of the GPS equipment, and post-survey data handling. Therefore, training is the basis for consistency in the execution of this protocol.

Implementation of Training

A critical component of the shoreline protocol is the GPS field survey of the shoreline. Successful execution of this task is contingent on properly trained personnel. The shoreline survey requires specific steps in preparation, collection, and processing. It is the responsibility of the NCBN to develop and deliver a training program to provide a scientific and technical foundation for consistent and accurate data collection.

Frequency of the Training Sessions

Training shall be conducted prior to initial implementation of the protocol and thereafter at a minimum interval of once every 2 years, or as needed due to staff or procedural changes.

Target Audiences

The Network shall provide training for two persons at each park. This will establish a core of competent and qualified shoreline surveyors. Additionally, data collection is improved when conducted by surveyors with local knowledge. Training two persons per park also helps to reduce problems related to staffing or scheduling.

Training Syllabus

The purpose of training is to develop and maintain competence in the following:

1. Basic Coastal Geomorphology
    a. Basic understanding of coastal process/response modeling
    b. Fundamentals of cross-shore profile development
    c. Development of swash on the beach face and its relationship with the shoreline
    d. Importance of non-storm conditions for seasonal measurement

2. Mission Planning – Choosing the right time to survey
    a. Seasonal timing
    b. Tides
    c. Storms
    d. Survey window

3. Conducting the Survey
    a. How to choose the right line
    b. Obstacle avoidance
    c. Dealing with shoreline perturbations

4. Using the GPS, including preparation of the equipment, setup and field usage.
    a. GPS equipment components and preparation – SOP#1
    b. GPS setup and operation –SOP #5
    c. Mounting the GPS –
        1. How to mount the antenna
        2. How to mount the data logger
        3. Receiver placement
        4. Use of the GPS with a backpack or lumbar mount
    d. Datalogger Setup (SOP#5) –
        1. Configuration
        2. Begin the logging process
        3. Conducting the survey
        4. Collecting benchmarks
        5. Finalizing the survey
    e. Filling out the Field Data Form (SOP #6)–
        1. File naming
        2. Form completion
        3. Note-taking

5. Park specific issues

.

6. Post survey processing – SOP#7
    a. Data downloading
    b. Data backup
    c. Initial quality assurance/quality control (QA/QC)

Geomorphologic Monitoring Protocol for Northeast Coastal and Barrier Network

Standard Operating Procedure (SOP) # 3

Site Location and Geographic Extent

Version 1.0 (June 2005)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This SOP illustrates the spatial extent of the GPS shoreline position survey for each of the ocean parks in the NCBN. The shoreline is highlighted by a solid red line in each of the figures. The spatial extent includes the entire ocean shoreline, and the inlet shoreline from the oceanside to distinct orientation change and a reduction of wave and current energies. This transition zone is approximated by the dashed red line on the figures. A dashed green line is used to designate areas not under Park Service jurisdiction but where collection would provide valuable information, such as in updrift or downdrift regions, or in areas between park units. Arranging for access to non-park areas is addressed in SOP#4. All maps are displayed in coordinates corresponding to data collection, UTM NAD83 Zone 18 North for ASIS, GATE, and FIIS, and UTM NAD83 Zone 19 North for CACO.

Assateague Island National Seashore

The ASIS shoreline extends for approximately 63 kilometers of ocean beach from Ocean City Inlet, MD. to Toms Cove Hook, VA. The northern terminus of the shoreline is at the jetty at Ocean City Inlet, MD. There is one transition area at the south end of the survey, on the distal end of Toms Cove Hook, VA. This transition area continues the shoreline around the end of the hook and terminates on the bayside where there is a distinct orientation change of the shoreline and a reduction of wave and current energies.

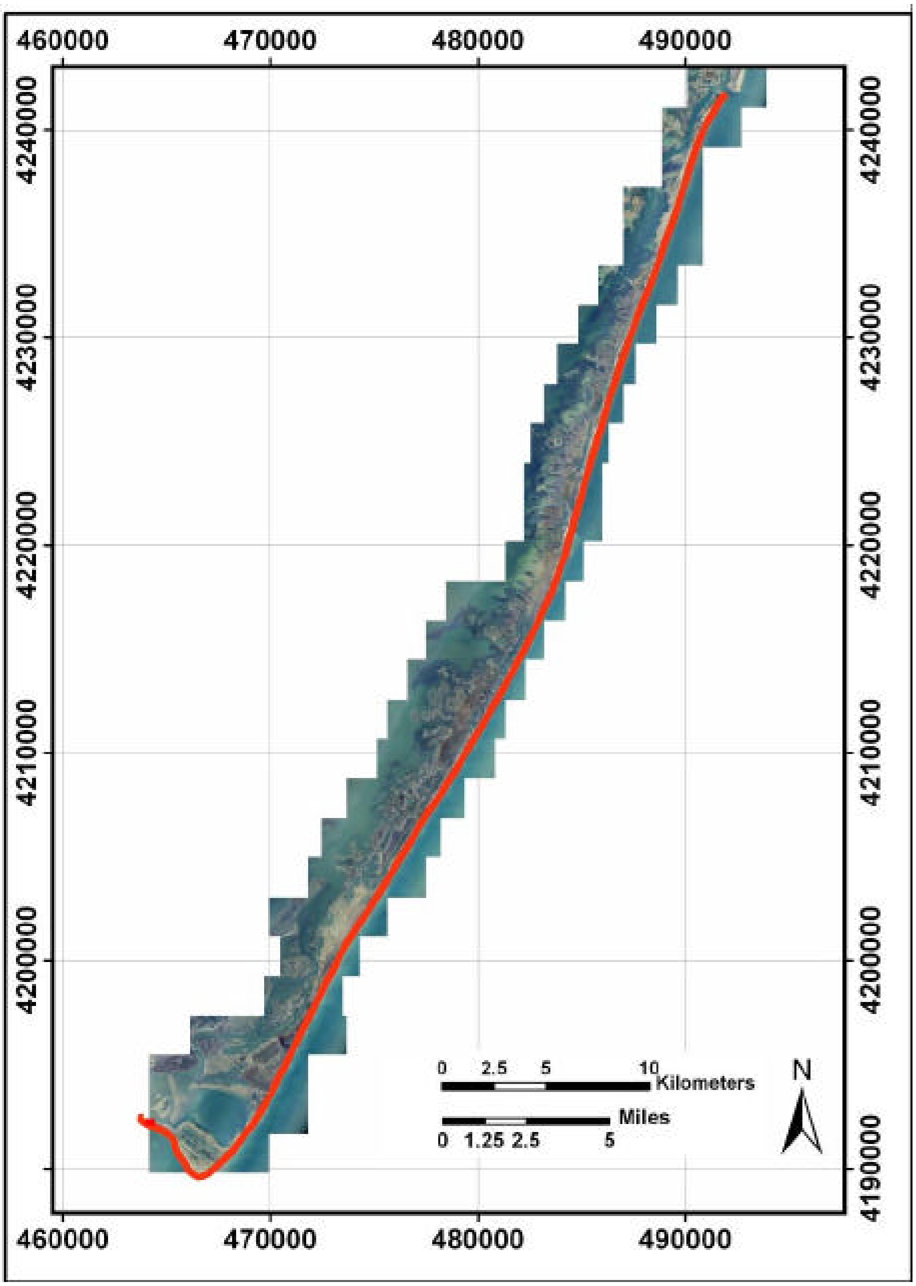

Figure 1 – Spatial extent of GPS data collection of the ASIS ocean shoreline. Image from USACE Baltimore District and NPS ASIS.

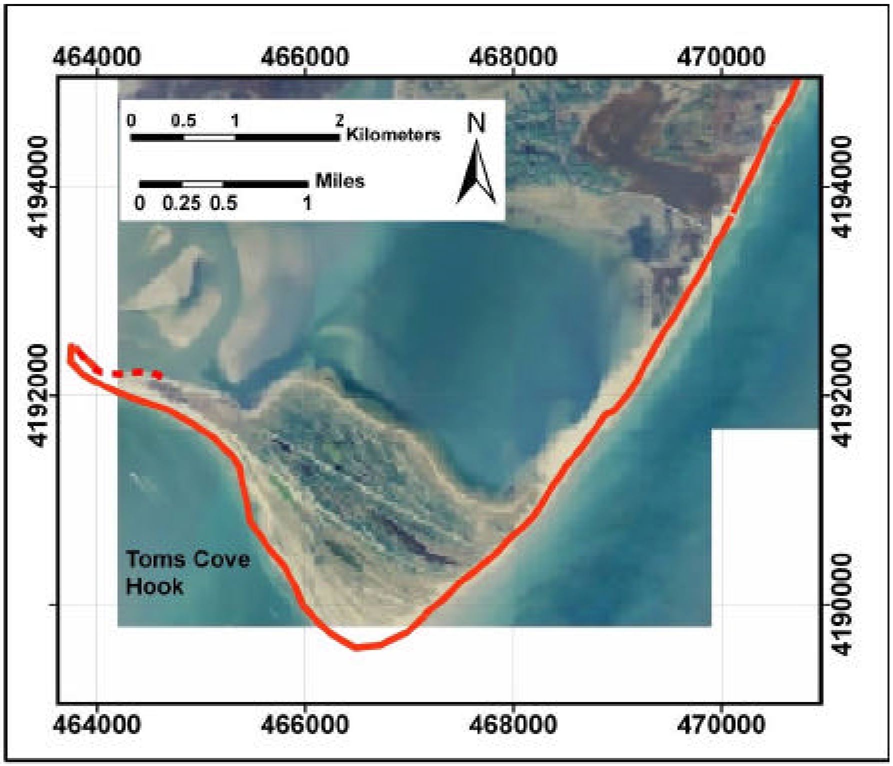

Figure 2. Spatial extent of GPS data collection of the ASIS transition zone at Toms Cove Hook, VA. . Image from USACE Baltimore District and NPS ASIS.

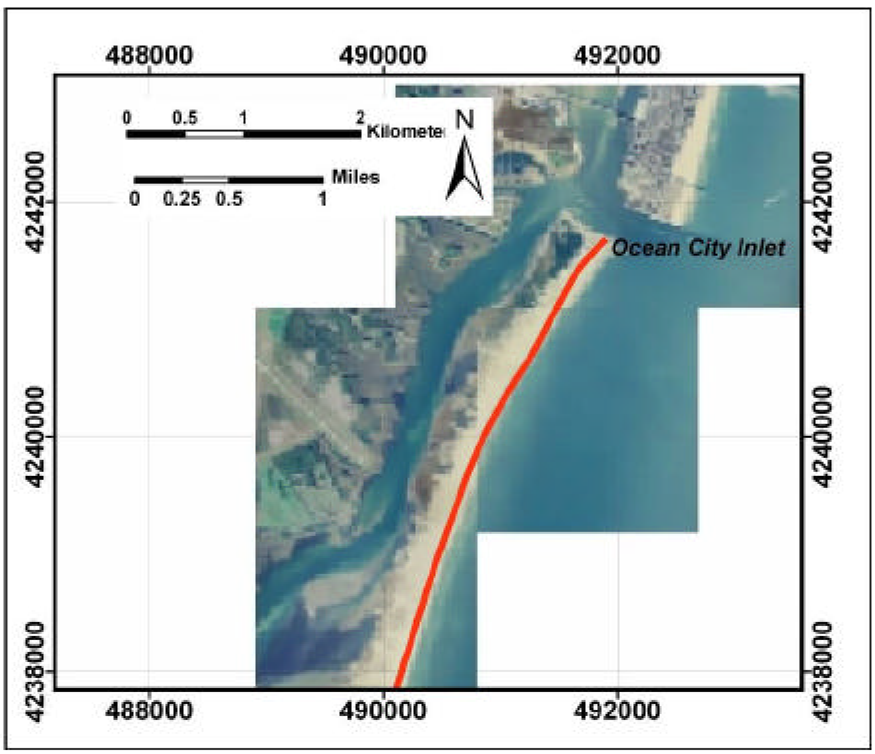

Figure 3. Spatial extent of GPS data collection of the ASIS shoreline terminating in the north at the Ocean City Jetty. Image from USACE Baltimore District and NPS ASIS.

Cape Cod National Seashore

The CACO shoreline extends for approximately 87 kilometers of ocean beach from Race Point to the southern end of Nauset Beach. There are a number of inlets along the ocean shoreline. They should be surveyed into the bayside (beyond the initial orientation change) to track changes in inlet position as the spits migrate. Both termini incorporate hook-like appendages. They should be surveyed to beyond their distal limits to record shifts and extensions.

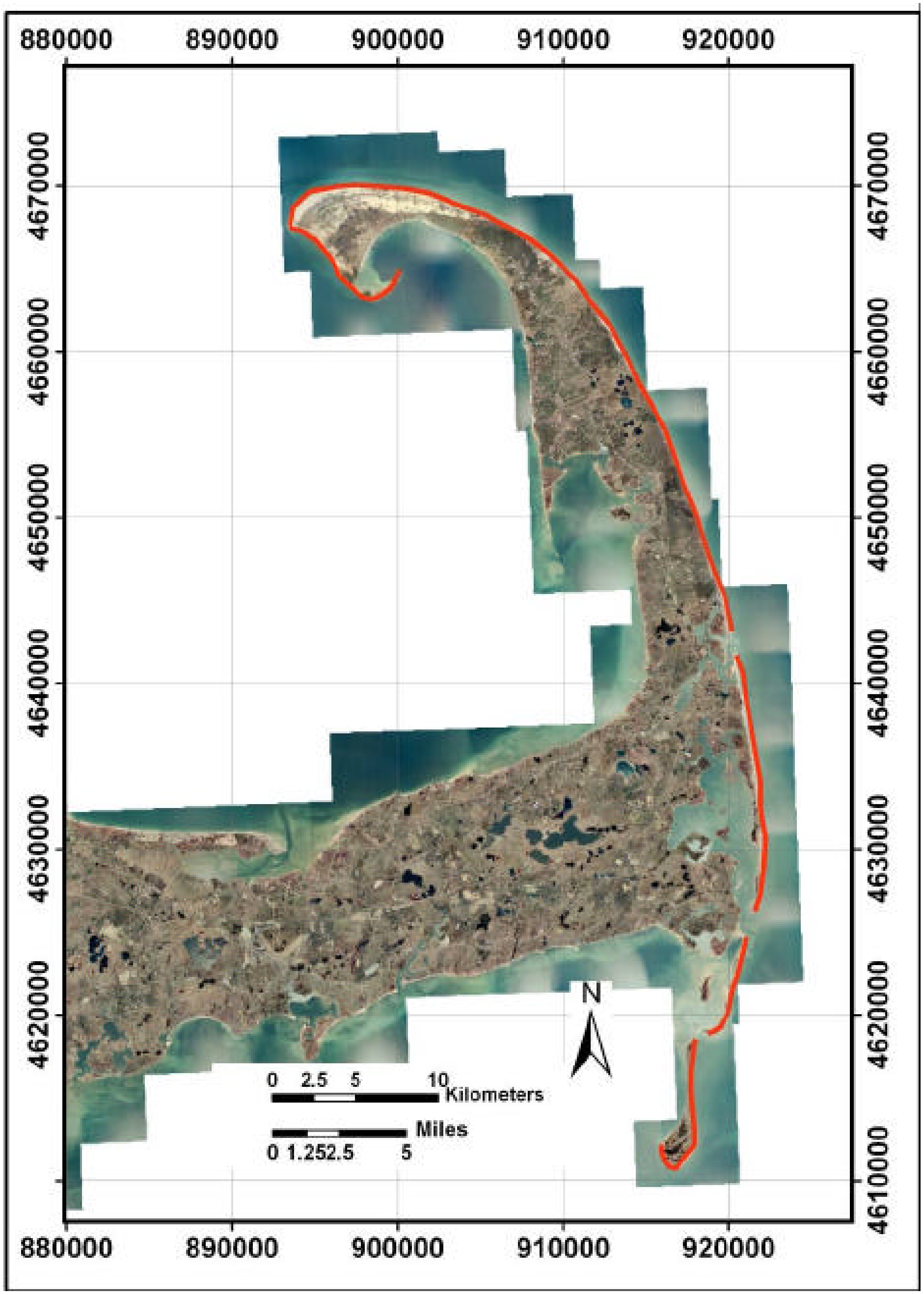

Figure 3. Spatial extent of GPS data collection of the CACO ocean shoreline. Image from NPS CACO.

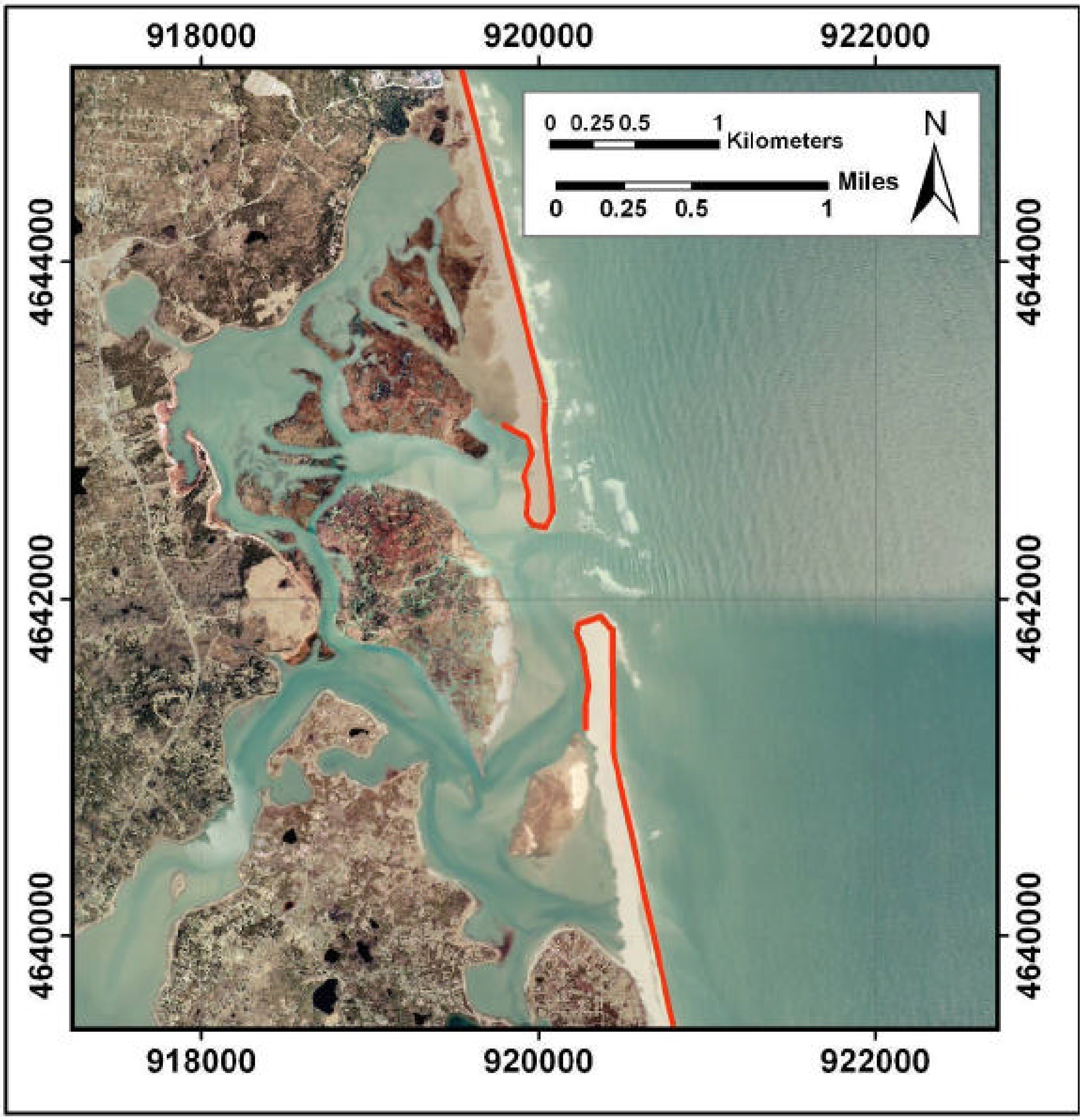

Figure 4. Example of a Spatial extent of GPS data collection for an inlet at CACO. Image from NPS CACO.

Gateway National Recreation Area – Sandy Hook (Figure 5)

The GATE-Sandy Hook shoreline extends for approximately 11 kilometers of ocean beach from the southern boundary with Sea Bright to the US Coast Guard property in the north. There is a jurisdictional transition area in the south, extending the shoreline updrift into the township of Sea Bright. At the northern terminus, the monitoring should extend into Sandy Hook Bay to record the elongation of Sandy Hook bayward.

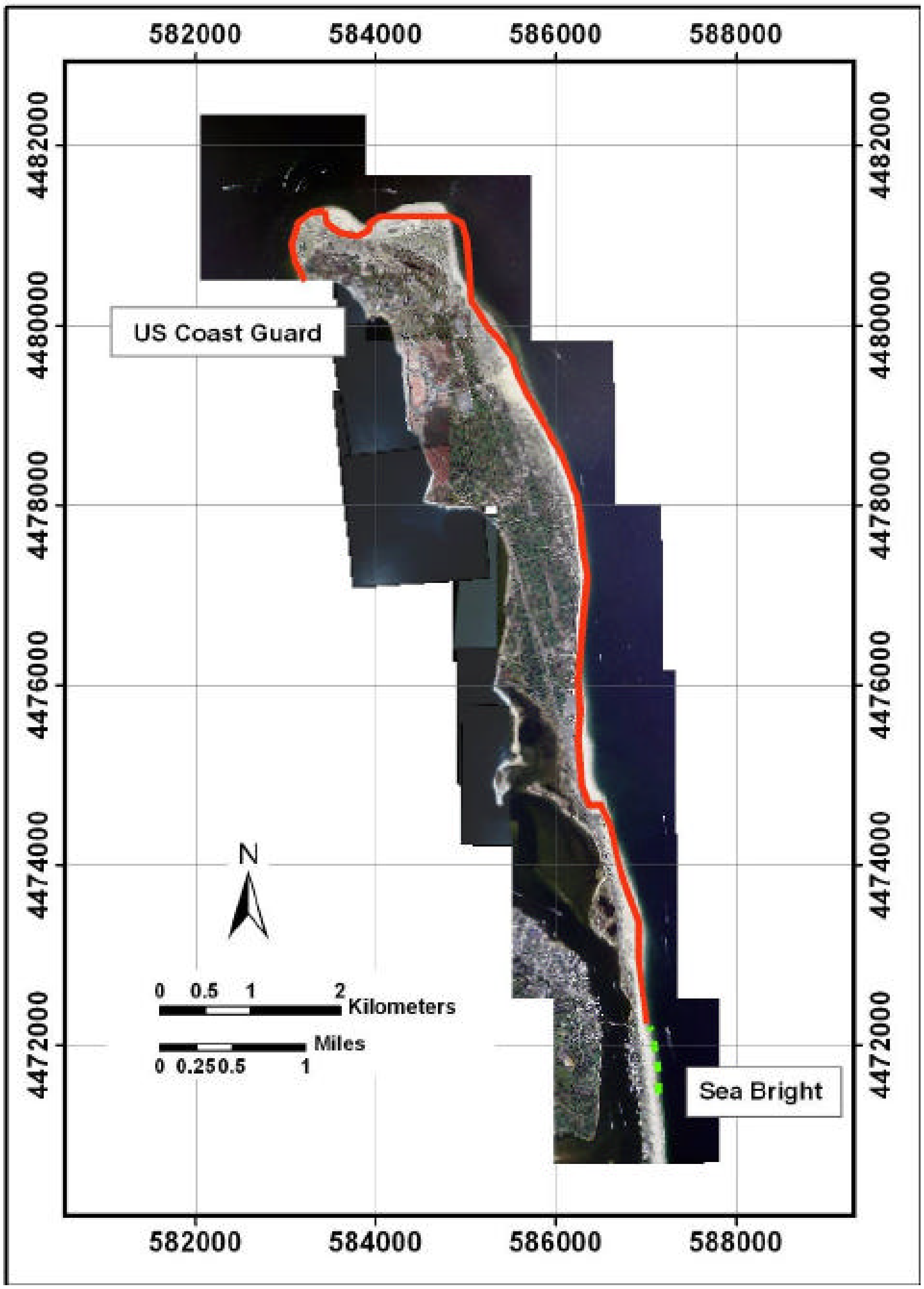

Figure 5. Spatial extent of GPS data collection of the GATE – Sandy Hook ocean shoreline. Image from NPS-GATE

Gateway National Recreation Area – Breezy Point (Figure 6)

The GATE-Breezy Point shoreline consists of the approximately 3.5 kilometers of ocean beach at Breezy Point and 4 kilometers of ocean beach at West Beach and Jacob Riis Park. Between these parks is a jurisdictional transition area fronting the Breezy Point Cooperative that is integral to the understanding of the shoreline change. The distal end of Breezy Point should be monitored into the bayside, including any beach accumulations west of the jetty. The eastern end of the survey is at the groin at the eastern end of Jacob Riis Park.

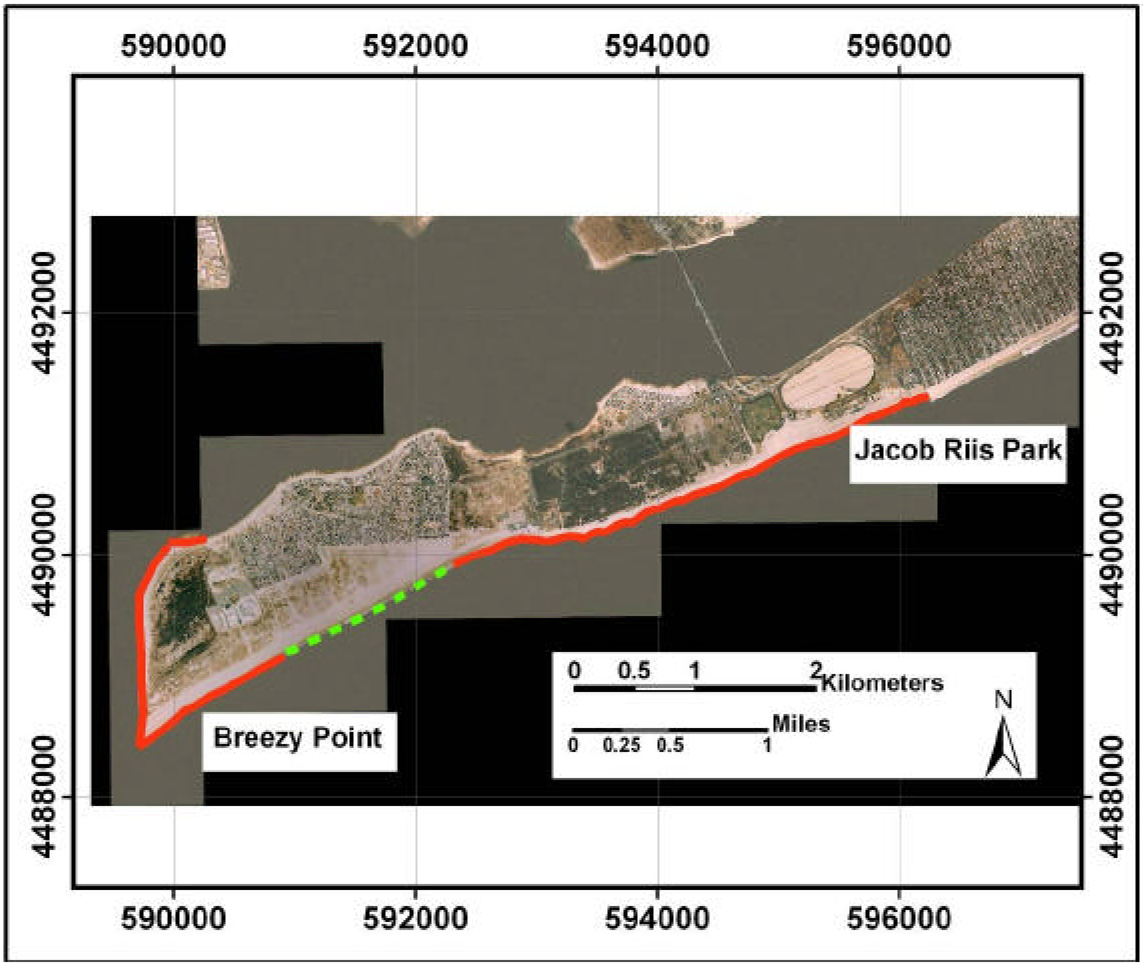

Figure 6. Spatial extent of GPS data collection of the GATE – Breezy Point ocean shoreline. Image from NPS-GATE

Gateway National Recreation Area – Staten Island (Figure 7)

The GATE-Staten Island shoreline is approximately 4 kilometers of ocean beach at Great Kills Beach, approximately 0.5 kilometers of beach at Miller Field Beach, and approximately 1.0 kilometer of beach at Fort Wadsworth. The westernmost end is the bulkhead for the boat basin. The easternmost end is the groin opposite the Verrazano Narrows Bridge. Between these park sections are jurisdictional transitions areas on privately owned and New York City properties. The totality of the public and private shoreline should be monitored as a continuous system.

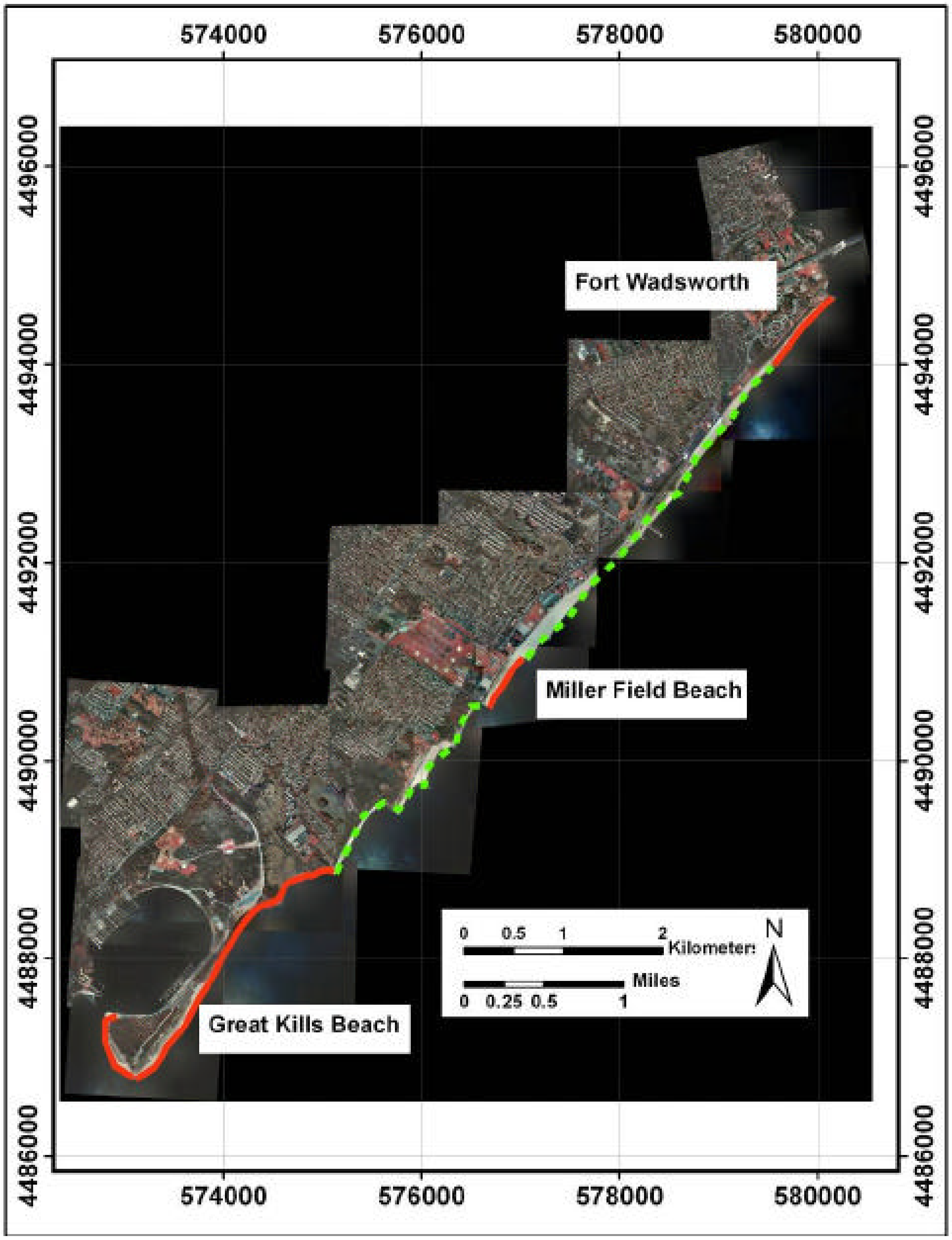

Figure 7. Spatial extent of GPS data collection of the GATE – Staten Island ocean shoreline. Image from NPS-GATE

Fire Island National Seashore (Figure 8)

The FIIS shoreline extends for approximately 51 kilometers of ocean beach from Democrat Point to Moriches Inlet. There are transition areas at the termini of the island. The western transition area is the expanding spit beyond the Fire Island Inlet jetty at the transition from ocean to bay processes. The eastern transition area is beyond the Moriches Inlet jetty at the transition from ocean to bay processes.

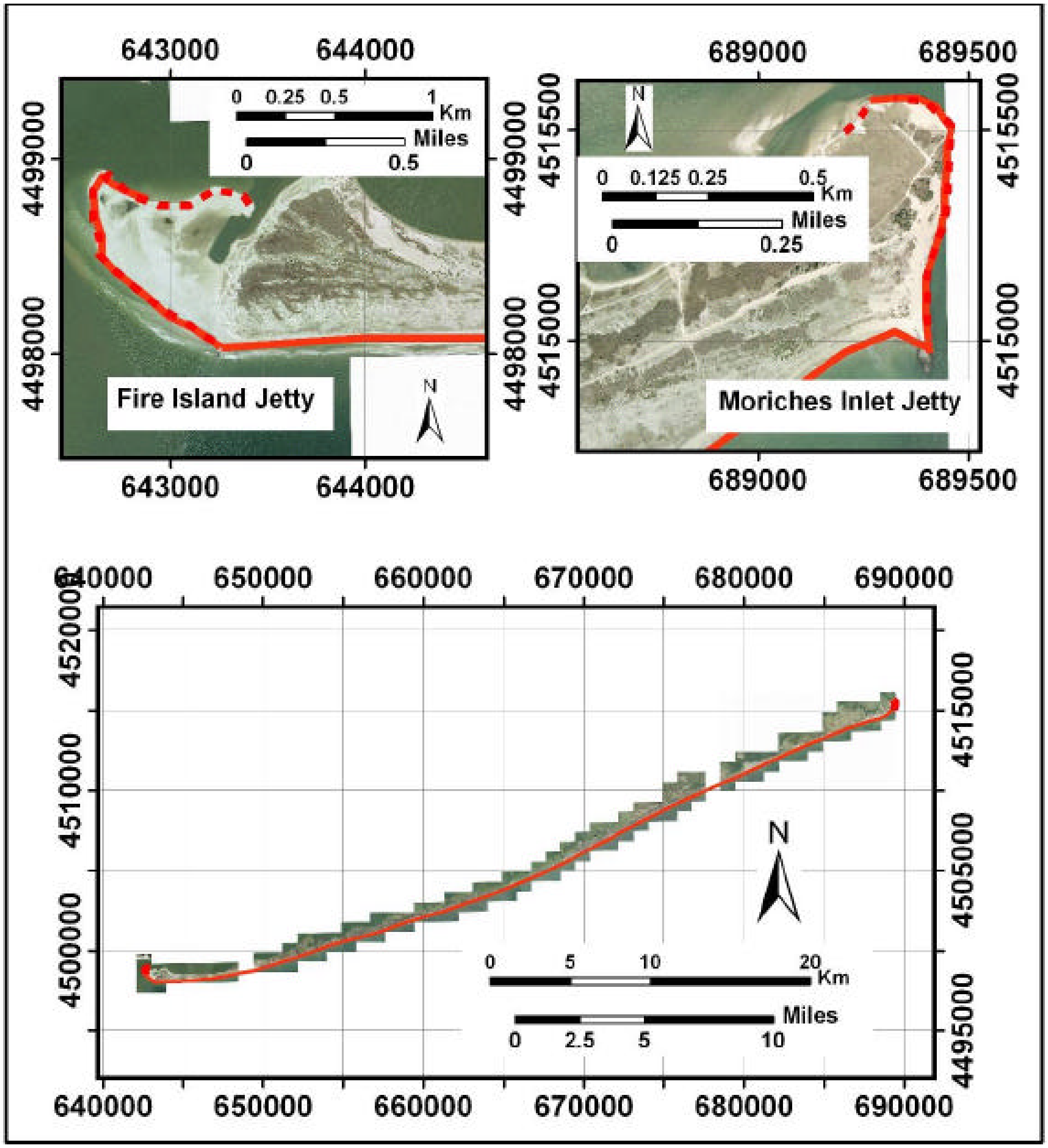

Figure 8. Spatial extent of GPS data collection of the FIIS ocean shoreline. Image from Suffolk County, NY and NPS FIIS.

Geomorphological Monitoring Protocol for the Northeast Coastal and Barrier Network

Standard Operating Procedure (SOP) # 4

Survey Timing and GPS Mission Planning

Version 1.0 (June 2005)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

The objective of this Standard Operating Procedure is to detail the process for selecting the temporal window for conducting the survey. The spring and fall seasons are the most likely times of the narrowest and widest beaches for the year (Trenhaile 1997). There is an opportunity to pre-select a survey period within these seasons that will maximize the opportunity to capture the seasonal variation. A standardized GPS survey window allows for comparability of the seasonal data set by collecting similarly-derived shorelines each year.

The comparability of shoreline positions collected with GPS equipment depends greatly on the timing of the record. The variables that determine the timing within the window are either predictable or observable and can be established in the preceding months, weeks, or days to maximize the repeatability and the efficiency of the survey. This SOP describes the procedure for the long-range identification of neap tide conditions as well as the satellite availability and geometric configuration (PDOP). It establishes the basis for short-term evaluation of storm conditions that may affect shoreline position. It addresses the variety of local resource-related variables that may constrain conducting the survey, such as endangered species zones or accessing restricted areas.

1. Creating the Survey Window

One objective of this protocol is to record the seasonal change in shoreline position. Over the course of a year, a sandy beach goes through a landward and seaward oscillation as the land/water surface contact (the shoreline) varies in position based on wave energy, sediment supply, and water level. These seasonal oscillations result in a narrowing and broadening of the beach. Observations of past summer and winter beaches at the Sandy Hook Unit of Gateway National Recreation Area demonstrate that beaches are at their narrowest by the middle of April (end of winter) and widest near the beginning of

October (end of summer). Based on these observations and the general trends on other beaches in the Northeast Coastal Barrier Network, the optimal time for recording the seasonal oscillation of the beach is a six-week window in mid-March to late April and in mid-September to late October.

2. Applying the neap tide variable

The NCBN parks have semidiurnal tides; there are two high tides and two low tides each day. Each month there are two periods when the difference between high and low tide (the tidal range) is at a maximum, SPRING TIDE, and when it is at a minimum, NEAP TIDE (Figure 1). There are also periods of mixed tides, where there is not a clean neap/spring signal. Times of reduced tidal range minimize water level variations within the monthly tidal cycle and therefore minimize variations in the shoreline position. Additionally, the elevated water levels relative to spring tide have the potential to have wave generated run-up (swash) overtop the berm crest. Therefore, although the neap high-tide swashline would be optimal, most high-tide swashlines that remain on the beachface would provide similar shoreline positions (SOP#6 – Figure 1). Consequently, the opportunity for shoreline collection in the six-week window is any day 1) within three or four days of a neap tide, or 2) any day in a mixed tide where water level elevations are less than those that occur within three days of the peak spring tide. At most eighteen days will be excluded by the spring tide water levels, leaving a potential twenty-four days for surveying each seasonal window.

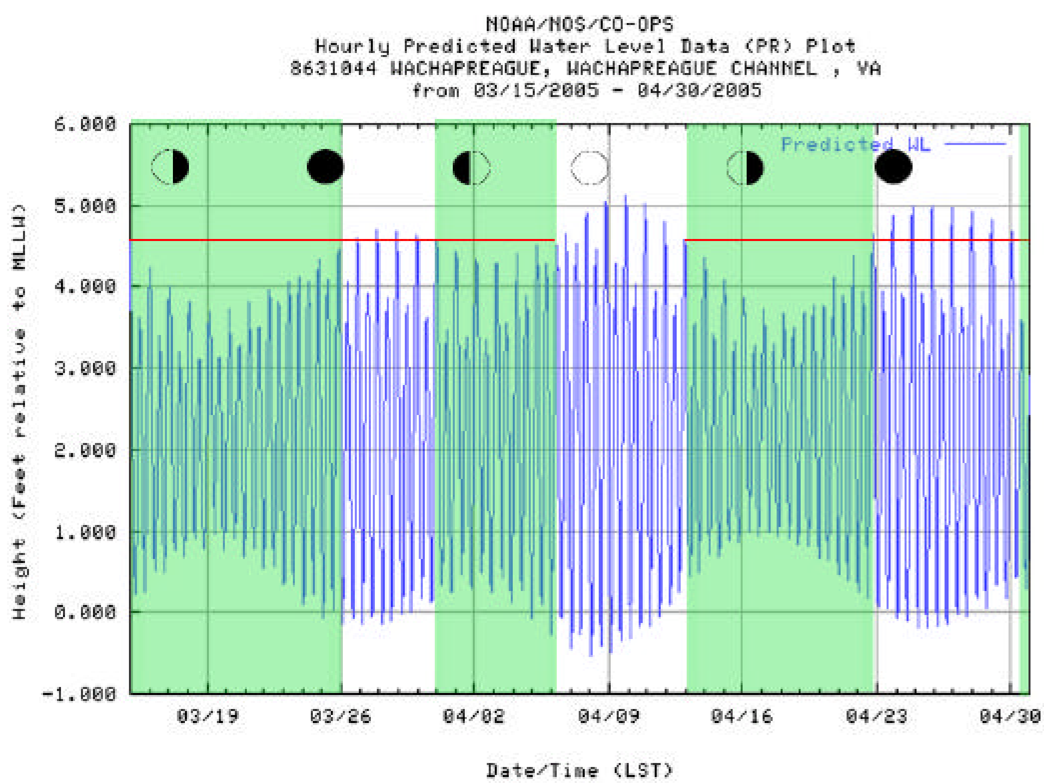

Figure 1. Predicted semi-diurnal tides (source: NOAA http://co-ops.nos.noaa.gov website). There are two uneven high and low tides each day. The spring tides occur on March 28th, April 9th and April 25th. Peak spring occurs on April 10th. The neap tides occur on March 20th, April 3rd, and April 18th. The red line is the water level

threshold established three days on either side of the peak spring tide. The days available for surveying are highlighted in translucent green. Moon phases associated with the tides are displayed at the top of the graph. The solid moon symbol represents full moon; the open symbol is new moon.

To determine the predicted tides for the six-week survey window:

1. Go to the predicted tide calculations available at the following NOAA website (http://co-ops.nos.noaa.gov)
2. Select the predictions link on the main page.
3. Choose the link for the current year.
4. Select "On the Fly Predictions"
5. Select the station from the drop down list according to its Station ID:
   - ASIS – 8557380 Lewes, DE or 8631044 Wachapreague Channel, VA
   - GATE – SHU – 853160 Sandy Hook, NJ
   - GATE – New York – 853160 Sandy Hook, NJ
   - FIIS - 853160 Sandy Hook, NJ
   - CACO – 8449130 Nantucket Island, MA
6. Set "Data Units" to **feet**
7. Set "Time Zone" to **LST** (local standard time)
8. Set "Data Interval" to **hourly.**
9. Set Begin date to one week prior to the first day of the six-week survey window, in form yyyymmdd (4 digit year, 2 digit month, 2 digit day)
10. Set End date to one week after the last day of the six-week survey window, in form yyyymmdd (4 digit year, 2 digit month, 2 digit day)
11. Select **View Plot** for graphical form or **View Data** for tabular form.

Within each of the six-week survey windows designated for the spring and fall surveys, there will many available survey days. The selected survey day should be the earliest convenient day in the window to allow for rescheduling if necessary.

3. Applying the Variable of Satellite Availability

The GPS data used to record shoreline positions are derived from the time signals sent from satellites. Each surveyed position requires simultaneous readings from a minimum of four satellites (Trimble manual; p. 21; April, 2004). Five or more satellites will slightly improve accuracy. More important than the finite number of satellites is the combination of their number and their geometry, called PDOP (position dissolution of precision). PDOP is a unitless number that describes the accuracy of the derived position based on satellite count and geometry. This numerical value may vary during the course of a survey and thus it needs to be considered in the date and time selection. A PDOP between zero and six is necessary to collect accurate and precise shoreline positions.

PDOP is a predictable value that can be plotted for the planned survey day. To view a PDOP plot, open the "Quick Plan" in Trimble Pathfinder Office (Figure 2) or access the satellite predictions by downloading the free mission planning software from the Trimble website (www.trimble.com). This plot identifies predicted PDOP values in advance of the survey. The "Quick Plan" plot represents the potential PDOP; this number will be increased (worsened) if the GPS receiver/antenna has an obstructed view of the sky, or if satellites become unavailable. PDOP fluctuates throughout the day as the satellites move in their orbits and change their relative geometry. PDOP values are generally within the zero to six threshold at all times in the Northeastern Parks, with occasional values greater than six midday. Predictions of PDOP value are valid for a maximum of thirty days in advance.

To obtain a prediction of PDOP prior to the survey:

1. Open the Trimble Pathfinder Office Software (TPO), or The Trimble Planning Software (TPS) – Planning Utility available at http://www.trimble.com.
2. Choose "Quick Plan" under the "Utilities" menu – TPO or the Station Editor under the File menu - TPS
3. Select the date corresponding with the first day in the survey window.
4. Select the time zone
5. Enter Elevation mask of 15
6. Select location of the city nearest the survey site, or enter coordinates within the park.
    - ASIS – Norfolk, VA
    - GATE AND FIIS – New York, NY
    - CACO – Provincetown, MA
7. Download the "Current Ephemeris Data" (Satellite Almanac) from http://www.trimble.com/gpsdataresources.html
8. Choose "Import" from the "Almanac" menu, select type ssf, and browse to the ephemeris file downloaded in step 5.
9. Choose "PDOP"or "DOP – Position" from the "Graphs" menu.
10. Verify that PDOP is between zero and six for at least the majority of the survey day. If the PDOP frequently exceeds six, reschedule the survey to the next day in the survey window, and repeat steps 3-10.

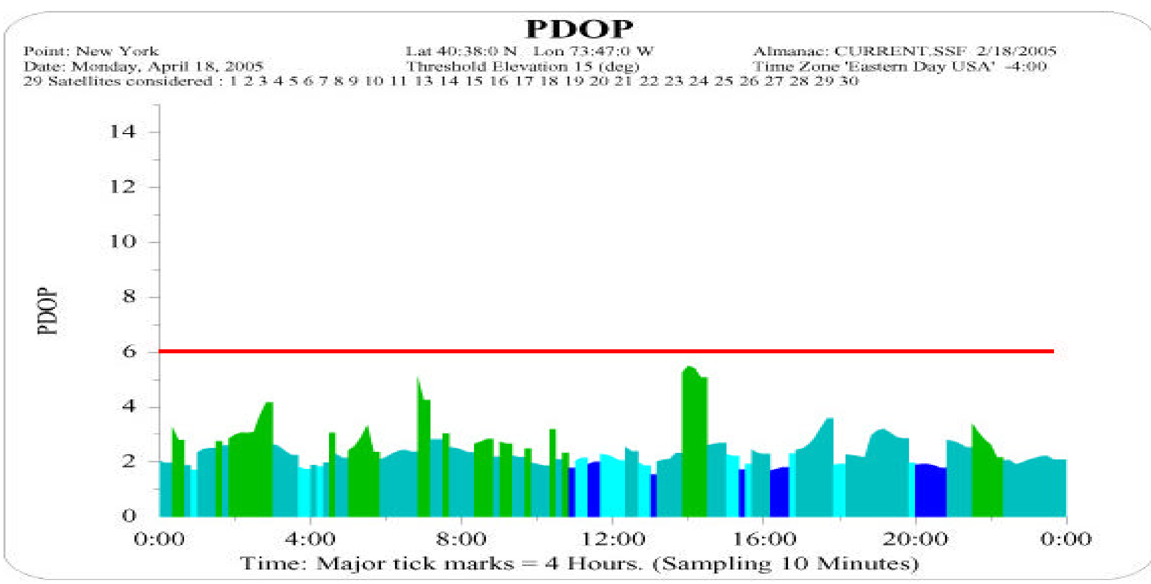

Figure 2. The distribution of PDOP using the Trimble Quick Plan software. PDOP values between 0 and 6 meet the survey criteria. The red line is the threshold PDOP value of 6.

4. Evaluation of a Storm Event on the Survey Window –

Because the objective of this monitoring protocol is to track long-term changes in the shoreline position, surveys should not occur within one week after a storm event. If the survey were to occur after a recent storm the shoreline position might represent short-term changes, and not the net or longer-term change in position due to changes in sediment budget.

A storm event, for this protocol, is defined as an event that produces an actual tide level of greater than one foot (0.32 meters) above the predicted high tide (Figure 3). A storm surge of greater than one foot at high tide may significantly displace the beach face and the subsequent position of the swash line. It can take up to a week for the beach to recover. Because the objective of this Protocol is to track long-term related to sediment supply, and not short-term storm related changes, it is necessary to allow the full recovery time prior to surveying.

Surge is determined by comparing the actual vs. predicted tides at the local NOAA tide gauge. The difference between the two data points represents the change in elevation of the water due to local conditions, referred to as surge. Stations to be used for surge calculation were selected because they have similar tidal ranges (approximately 5-6 feet (1.6-1.9 meters)) and therefore the one foot surge threshold is consistent and proportional to this range.

Six days prior to the planned survey day:

1. Access the NOAA tide gauges through the CO-OPS website at http://co-ops.nos.noaa.gov.
2. Select the "Tides Online" link.
3. Choose State Maps, and select the appropriate station:
   - ASIS – 8557380 Lewes, DE or 8631044 Wachapreague Channel, VA
   - GATE – SHU – 853160 Sandy Hook, NJ
   - GATE – New York – 853160 Sandy Hook, NJ
   - FIIS – 853160 Sandy Hook, NJ
   - CACO – 8449130 Nantucket Island, MA
4. View the plot of water levels. The data may also be viewed in tabular form by clicking the **Data Listing** link. The difference between the **Prediction** and **Actual Observation** is the **Residual**, or storm surge**.** It is this residual value that must not exceed one foot at high tide in the week prior to the chosen survey day. If the presence of a storm surge prevents the shoreline survey from occurring during the allotted timeframe, reschedule the survey to the next convenient day in the survey window.
5. Steps 1-4 should be repeated four and two days prior to the survey and on the morning of the survey because the site only displays information for the previous two days.

A longer record of predicted and actual values is also available through the "Preliminary Water Level, US and Global Stations" link on the NOAA CO-OPS website. To determine the surge values, a calculation must be made of the difference between the observed and the predicted values. Use comparable datum (Mean Lower Low Water, for example) and time frames (Local or Greenwich time) to avoid errors of offset in elevation and time.

- The final step in determining the survey date is verification that the survey day is in a "non-storm" condition.

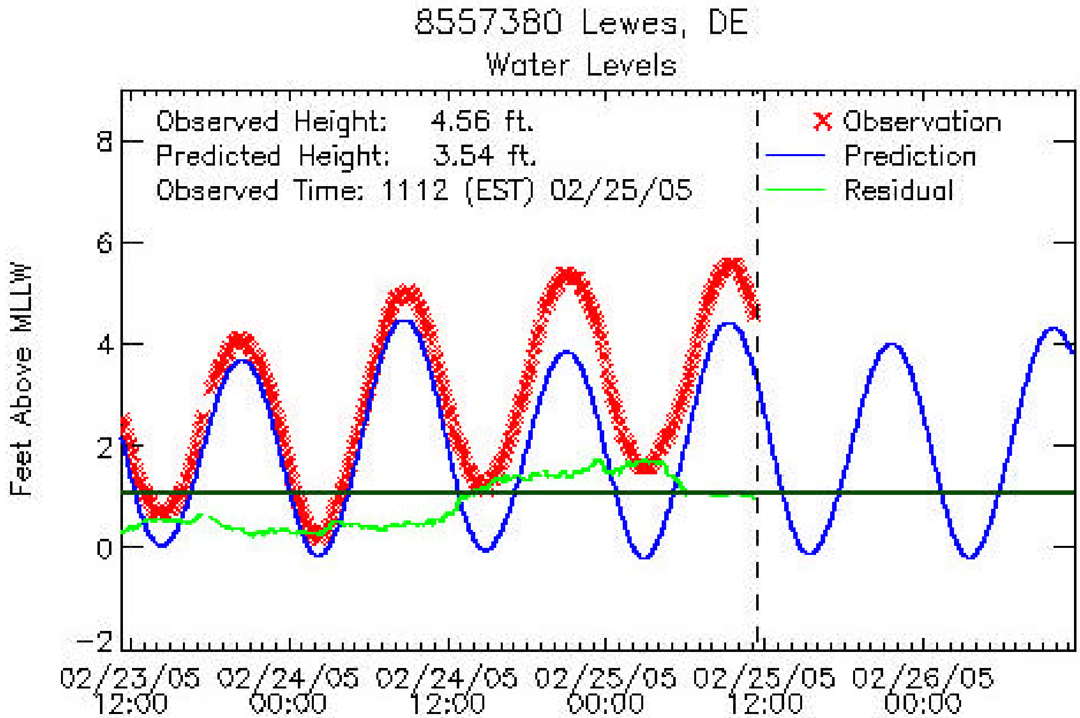

Figure 3. The depiction of water level and surge at Lewes, DE for the period February 23rd – February 25th, 2005 (Source: NOAA http://co-ops.nos.noaa.gov). The horizontal dark green line represents the one foot surge threshold. Feb 23rd – Feb 24th at noon would be acceptable survey days. On February 24th at 9pm, a surge (light green line) of greater than one foot occurs at high tide, and therefore the day is classified as stormy. The survey should not occur within one week of this condition.

5. Resource Related Issues – A complete shoreline position survey requires access to the beachface and to reference monuments over the course of the survey. There may be time periods when access may be restricted to portions of the beach due to resource management issues that overlap with the survey window, such as periods of endangered species nesting, or park activities. Advanced planning is required to ensure complete spatial coverage.

a. Rare, Threatened, and Endangered Species – If the beaches are closed for resource related issues such as bird nesting, surveying the shoreline may require the assistance of Natural Resource staff. The surveyor may require an escort through these areas, or the shoreline may need to be walked. If there are substantial areas that must be walked, allow extra time for the survey. If access to the shoreline will be completely restricted, plan the survey for an alternate day.

b. Other Constraints – There may be access restrictions or other activities that will need to be addressed through park management. Scheduled events on the beach may restrict vehicular access to portions of the shoreline. If an event is planned on the survey day, allow for extra time to walk the survey, move the survey to one of the other days in the survey window, or, if necessary, reschedule the survey to a different day.

6. Points of Contact – Resource and other related issues may require cooperation between multiple agencies and divisions within the shoreline survey area. A contact list should be kept up-to-date and stored with the GPS equipment. Contact should be made with any cooperating or neighboring agency, including management at State Parks, County Parks, other Federal Agencies, or other jurisdictional partners, in the weeks prior to the survey.

Geomorphological Monitoring Protocol for the Northeast Coastal and Barrier Network

Standard Operating Procedure (SOP) # 5

Basic GPS Settings for Position Collection

Version 1.0 (June 2005)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This SOP details the critical settings of the sub-meter GPS system for collecting the position of the shoreline and reference points, and gives a specific example of settings for the Trimble ProXR with TSC1 datalogger. There are a number of parameters that need to be preconfigured within the GPS system so that data collection is within the sub-meter quality specification. Additionally, standardizing the criteria for collecting GPS positions assures that the survey is replicable and comparable. Once the datalogger is configured, the settings should be re-confirmed immediately prior to conducting the survey.

Critical GPS System Settings

The following values need to be set on any GPS unit used to execute the ocean shoreline position protocol. They are set on the GPS datalogger prior to the survey.

1. **Point feature – 1 second between points**

   The timing of Point Features indicates the frequency at which observations will be recorded.

2. **Line feature – 1 second between points**

   Similar to Point Features, the Line Feature setting determines the frequency of points along the line. This is the setting that is used for mapping a continuous feature, such as the shoreline.

3. **Minimum observations for point position – 12 positions**

   The GPS system uses a minimum number of observations to determine an individual point. A greater number of observed positions results in a more accurate feature. The setting value was determined to balance accuracy and field time.

4. Logging options – log all data available

5. Elevation mask – 15 degrees

The elevation mask is the angle relative to the horizon above which satellites will be used to generate the GPS positions. Satellites very low on the horizon degrade the PDOP and have signal errors due to increased distance that the signal travels through the atmosphere, and should therefore not be used.

6. SNR (Signal to Noise Ratio) – 6.0

The signal to noise (SNR) ratio is a representation of the amount of usable information received versus the amount of discarded information (noise). A threshold of **6** is necessary to achieve sufficient signal for sub-meter positions.

7. PDOP mask – 6.0

The PDOP value is the unitless representation of satellite geometry. A PDOP threshold of **6** is necessary to achieve sub-meter accuracy.

8. Apply real time – no

Application of real-time data correction precludes post-processing with some systems. In order to guarantee the ability to post-process, real time data correction should be set to **NO** at all time. If the individual GPS allows post-processing of real-time corrected data, **Apply real-time** may be set to **YES**.

9. Height – (height of antenna)

Because only horizontal positions are being used, vertical elevations are not relevant. However, an approximate elevation should be entered to avoid complications in position calculations.

10. Coordinate System – UTM 18North or 19North for CACO only

The Coordinate System Zone details the reference system on which the data will be projected.

The following is a complete listing of settings for a Trimble ProXR with a TSC1 datalogger. Similar settings will be used on all GPS systems.

ProXR Operation and Navigation (TSC1 example):

1. **Powering On/Off:**
   a. **On** – press the green button on the lower left of the datalogger keypad
   b. **Off** – press and hold the green button on the lower left of the datalogger keypad
   Note: Connection of the receiver to the datalogger may power on the system automatically and drain the batteries.
2. **Navigating the menus:**
   a. Use the round up/down arrow button to toggle menu choices
   b. Use **ENTER** key to choose/open a highlighted item
   c. Use **ESC** key to cancel an action, escape/close a menu, end a feature, or return to a previous menu.
   d. Use **MENU** key to display the Main Menu
   e. Use **NEXT** key to toggle through all open menus or display windows

f. Additional functions or choices may be displayed along the bottom of the screen. These correspond with the **F1**, **F2**, **F3**, **F4**, and **F5** keys along the top of the datalogger keypad. Choose these options by pressing the corresponding key.

g. If a value is changed, use the navigation arrows (not ENTER) to store the new value.

ProXR Configuration Settings for GPS shoreline position collection

Navigation of the ProXR is through a series of menus and submenus. Each of these submenus needs to be configured. Whereas some of the settings are not used or not required, they must be entered to ensure there are no inconsistencies in the setup. Items bolded and underlined in the submenus below indicate values to be entered. Items that directly affect the quality of GPS positions and position collection are further elaborated.

1. **Logging Options Submenu**
   a. Point Features = **1** seconds
   b. Line/area = **1** seconds
   c. Not in Feature = **None**
   d. Velocity = **None**
   e. Confirm end feature = **No**
   f. Minimum posns = **12**
   g. Carrier Mode = **Off**
   h. Minimum Time = **10 ms**
   i. Dynamics code = **Land**
   j. Audible Click = **Yes**
      Items k-m are quality control information related to each data point collected. They are used in the post-processing phase.
   k. Log DOP data = **Yes**
   l. Log PPRT data = **Yes**
   m. Log QA/QC data = **Yes**
2. **Position Filters Submenu**
   a. Position mode = **Manual 3D**
      The position mode describes the type of point being collected.
   b. Elevation Mask = **15 degrees**
   c. SNR mask = **6.0**
   d. PDOP mask = **6.0**
   e. PDOP switch = **6.0**
   f. Apply real-time = **No**
3. **Antenna Options Submenu**
   a. Height = approximate (**1-3 m**)
   b. Measure Vertical = **No**
   c. Confirm = **Per File**
   d. Type = **Integrated GPS/Beacon**
   e. Part Number = **29653-00**
4. **Coordinate System**
   a. Zone = **18 North** for FIIS, ASIS, GATE (**19 North** at CACO only)

b. Datum = **NAD 1983 (Conus)**
c. Altitude units = **Meters**
d. Coordinate units = **Meters**
e. Altitude reference = **MSL**
f. Geoid Model = **DMA 10x10 (Global)**

5. **Units and Display Menu**

The units and display items reflect only how data are displayed on the datalogger screen, and does not represent how data are recorded. These items may be changed if desired by the field data collector.

a. Distance = **Meters**
b. Area= **Square Meters**
c. Velocity = **Miles/hour**
d. Angles = **Degrees**
e. Angle Format = **DD MM SS.ss**
f. Order = **North/East**
g. North reference = **True**
h. Declination = **Auto**
i. Null String =?
j. Language = **English**

6. **Time and Date Menu**

a. 24-hour clock = **Yes**
b. Time = **[Greenwich Mean Time]**
c. Date Format = **MM/DD/YYYY**
d. Date = **[Today's Date]**

7. **Hardware menu** (recommended settings)

a. LCD contrast = **45%**

The LCD contrast may need to be changed depending on the ambient light conditions on the day of surveying. Higher LCD contrasts will use the external batteries faster than lower levels, so set the equipment at the minimum usable level.

b. Backlight = **Off**
c. Low Voltage charging = **Off**
d. Auto Shutoff = **20**
e. Beep Volume = **High**

A high beep volume is essential to be able to hear any audible signals in the field.

f. Free space = [amount of storage space on datalogger]

The amount of free space available can be increased by deleting old data files. Only delete data files if the data have been downloaded and backed up (SOP#7).

g. PC card free space = N/A
h. Battery source = [internal or external]
i. Internal Battery = [percent charge remaining]
j. External = [N/A if not connected to GPS; percent charge in camcorder batteries]

All batteries should be fully charged when preparing for the survey.

k. Software version = [version number]

Geomorphological Monitoring Protocol for the Northeast Coastal and Barrier Network

Standard Operating Procedure (SOP) # 6

Conducting the GPS Shoreline Survey

Version 1.0 (June 2005)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

The objective of this SOP is to detail the procedure for identifying and systematically recording the position of the shoreline. To reduce the effects of short-term variations in shoreline position, the optimal shoreline would be collected during a period of low tidal range (neap-tide) and during non-stormy conditions (SOP#4). Therefore, the target shoreline, for the purposes of this protocol, is the neap high-tide swash line (Figure 1). It is a representative qualitative feature that identifies a water/land surface intercept (a shoreline). It is easily collected using existing equipment, it is feasible to implement on the network level, and its collection as a dataset allows it to be compared to archives of historical shoreline positions.

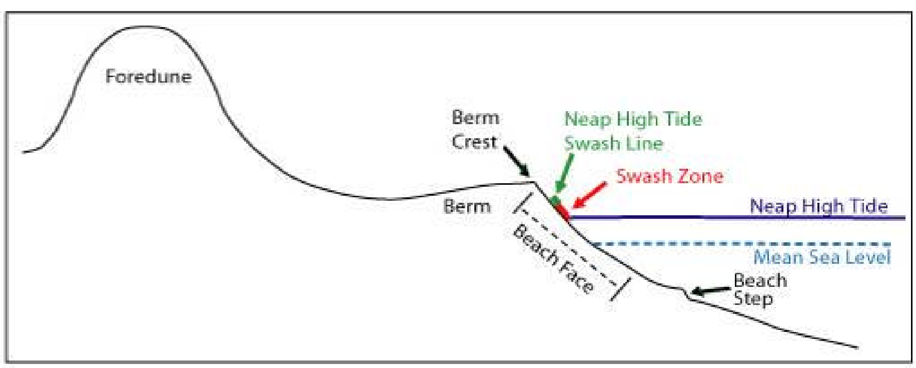

Figure 1. Conceptual dune-beach profile showing the juxtaposition of water level, topographic features, and the identification of the neap high-tide swash line.

A preliminary part of the monitoring program is the selection of a shoreline survey window using the procedure in SOP#4 – Mission Planning. Unless constrained by a storm event or very high spring tides, the survey is scheduled for the first convenient high-tide in mid-March to late April (spring survey) and mid-September to late October (fall survey). The shoreline data collection will begin one to two hours after high tide to allow sufficient time for the water level to recede. This will expose sufficient beach face for collection to be possible and leave a clearly identifiable swash mark.

This SOP consists of four components. The first component is the initial preparation procedures that include the visual identification of the line, initialization of the data form, and collection of the first benchmark. The second component is the survey of the shoreline with the GPS. The third component deals with natural or artificial perturbations to the shoreline, including natural features (cusps, scarps), hard structures (groins, jetties), and human interference (anglers). The fourth component ends the survey and records the position of the final benchmark.

Component 1 - Preparatory Procedures:

Before beginning data collection, go to the beach and visually confirm that the swash line is identifiable and on the beach face. The line may be a damp sand and shell hash line, a debris line, or some combination of these characteristics (Figure 2). The swash line's presence on the beach face assures that no unusual wave or water levels were present. If the swash line is landward of the berm crest it is likely that the surge and tides that created this line exceeded the threshold for a low tide and/or non-stormy conditions. Therefore, the survey must be rescheduled using the procedures described in SOP#4 – Mission Planning.

Figure 2. This high-tide swash line (dashed red line), on the beach face, is composed of damp sand, shell hash, and small amounts of debris.

There may be more than one shell hash/debris line on the beach face. The more recently-deposited high-tide swash lines are more distinctive than older, more muted lines (Figure 3). Less distinct lines will also be deposited as the tide recedes (Figure 3). It is essential to survey the most recent-and-highest of the shell hash lines on the beach face.

Figure 3. This recent high-tide swash line (dashed red line) is a damp sand and shell hash line with debris. There are older more muted lines landward and there are lower lines seaward.

Initiate the Field Data Form

The Field Data Form (FDF) is used for all field notations. This information is necessary for post-processing of the data and facilitates the generation of accurate metadata. Once the shoreline has been visually identified on the beach face, fill in the LocationID, Observers Name, Protocol Version, Date, and GPS filename on the FDF using the following formats.

FDF-a*. LocationID – The 4 character park identifier, CACO, ASIS, GATE, FIIS, and the unit if applicable. For example, ASIS or GATE-SHU.

FDF-b. Observers Name (First Middle Last) – Write the surveyor's full name.

FDF-c. Protocol/SOP Version (GMP version #/SOP version #) – Version of the protocol used to guide field data collection. Example is GMP v1.0/SOP#6 v1.1

FDF-d. Date (mm/dd/yyyy) - Write the date in the format shown. Include the forward slash. Examples are 05/05/2005 and 12/31/2005.

* Items FDF-a – FDF-i represent entries on the Field Data Form. .

FDF-e. GPS Filename - Log the GPS filename generated by the datalogger.

FDF-f. GPS system – Type and brand of GPS system components used

These initial values may be entered prior to going to the field. Additional items on the FDF (Start Time, End time, Benchmark Notes, and other Notes) will be logged later in the survey or can be derived from the GPS file in the post-processing phase. Either the FDF or the comment/note function of the datalogger will be used to record observations and notes during the survey.

Geomorphologic Monitoring Protocol

Field Data Form - GPS Shoreline Survey

LocationID: FIIS
Observers Name: Jeffrey Peter Pace
Protocol Version: 1
Survey: **GPS Shoreline**
Date (mm/dd/yyyy): 01/26/05
Start Time (hhmm): 0800
End Time (hhmm): 1350
GPS System: Trimble ProXR with TSC1
GPS Filename: 12489564

Benchmarks					Notes	
Time	Point #	Benchmark Code	Notes (Condition, etc...)		Time	Description (Reason for notation)
0805	1001	CORPS F15	found in good condition		1132	Shoreline ended at point 2472 because of offset at groin. New line started at point 2473
1230	3427	CORPS F46	appears damaged, not confident in location		1300	data logger observed to not be recording, returned to 1230 benchmark and retraced line
1345	5210	CORPS F62	found in good condition			

Figure 4. Example of entries on the Field Data Form.

Incorporating Benchmarks into the Survey

All GPS positions are independent data points, and collecting reference locations (benchmarks) at a variety of locations and times will help to verify the continued precision of the GPS measurements of the shoreline position. Benchmarks are high quality reference points and one should be collected at the beginning of the survey.

To collect a reference point, position the GPS antenna directly over the benchmark and begin point feature collection. The GPS records the position of the antenna, so do not begin collection until the antenna is directly over the feature to be recorded. The starting benchmark is the first position (point feature) to be recorded.

1. Position the antenna over benchmark.
2. Record the benchmark as a point feature.
3. Store the benchmark and log the benchmark information on the FDF or make comments in the datalogger.

Record the benchmark information on the FDF using the following format:

FDF-**g. Benchmarks –** Note the time and point number of each benchmark recorded, as displayed on the GPS datalogger. The Benchmark Code refers to the unique benchmark identifier stamped on the benchmark. In the notes section, record the condition of the benchmark, especially if the condition is degraded or questionable.

Component 2 - Shoreline Survey Procedure

Beginning the Survey

After the first benchmark has been collected, mount the GPS antenna on the quad or 4x4 vehicle. Position the vehicle at the starting point for the shoreline collection. Place the antenna between the observer's position and a front tire (or over the driver's side tire on a 4x4 vehicle) to make it easier for the operator to accurately drive the shoreline. Regardless of the placement of the antenna on the vehicle, the GPS always records the position of the antenna. Once the antenna is directly over the shoreline, collection can begin. Make a note on the FDF of the starting point number and time, or obtain this information from the GPS file after the survey.

FDF-h. Notes – Anytime data collection is started, stopped, or paused, a note should be made on the Field Data Form or in the datalogger. Notes should be as detailed as possible, and must include point numbers (if applicable) and detailed descriptions. These notes are crucial in the QA/QC procedure and are the only documentation for decisions made in the field. Do not use abbreviations in note taking.

To begin data collection

1. Open the pre-configured GPS file
2. Pause the datalogger
3. Begin the line feature
4. Unpause logging to start the datalogger and begin the line feature
5. Ensure that the positions are being collected by observing the point count increasing and/or hearing the audible clicks.
6. Once logging is verified, proceed to drive the shoreline at approximately 10 mph, maintaining the antenna's position over the high-tide swash line.

Following the Shoreline

The natural shape of the shoreline may be linear, it may be cuspate (scalloped), or there may be broad sweeping curvilinear forms in the beach (Figure 5). These configurations may be indicative of a change in processes and are important to the shoreline collection. Make every effort possible to maintain antenna position over the high-tide swash line while following these features.

Figure 5. Example of a cuspate shoreline where the high-tide swash line tracks the shape of the cusps. Cusp dimensions are approximately 10-15 meters alongshore and the swash line should be followed as part of the shoreline survey.

If the features are very small (on the order of a few meters), driving the line will naturally average these features because it would be impractical to position the antenna to follow every nuance of the line (Figure 6). The dashed line in Figure 6 shows the path that should be taken in surveying the very irregular swash line on a nearly linear beach face. These small-dimensioned irregularities are related to the micro-topography of the beach and are therefore representative of short-term conditions, rather than long term (seasonal and longer) trends. Large dimension cusps, on the order of 50 meters or greater, may be indicative of sediment budget processes that are representative of trends of seasonal and annual time scales, and therefore their location should be recorded. Cusps on the scale of 10s of meters should be followed wherever possible.

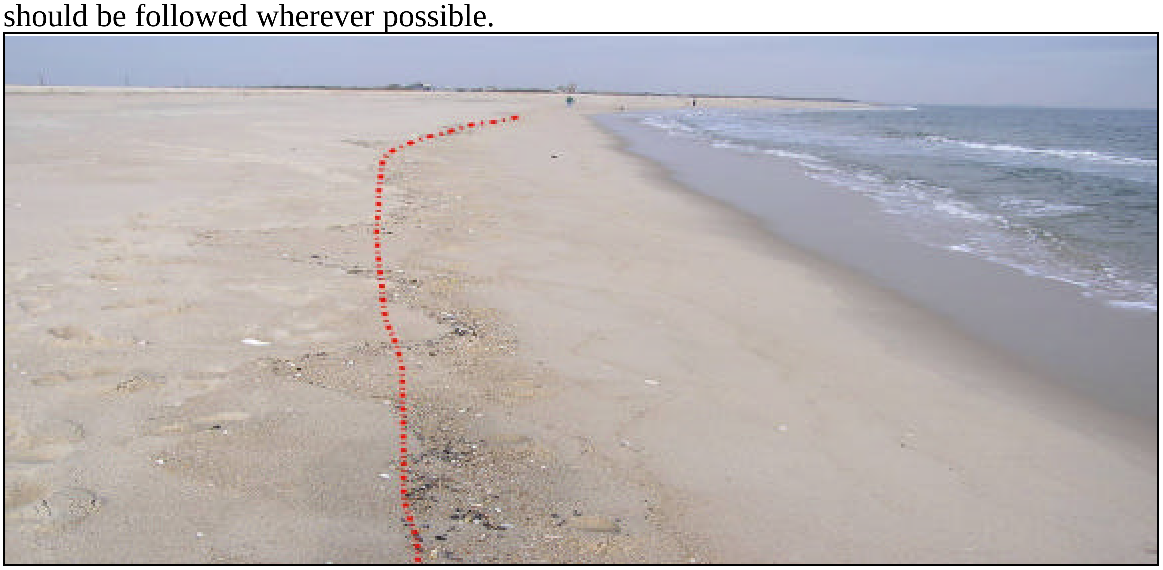

Figure 6. The high-tide swash line (red dashed line) has small irregularities that will be smoothened, recording the average position of the line.

Verification of the Survey

Every 15 minutes, stop driving and verify that points are still being collected, and visually note the location. Verification of the data logger's functionality reduces the potential loss of data. If points are no longer being collected, rectify the problem and return to the previous stopping point and resume shoreline collection. These brief stops provide an opportunity to survey supplemental benchmarks if they are available and nearby. Anytime logging is stopped and restarted a note should be made on the Field Data Form or in the datalogger.

During the stop:

1. Confirm points are still being collected
   a. If points are being collected, continue survey
   b. If points are not being collected, rectify problem, and return to last known recorded point location and resume shoreline survey.
2. (Optional) If a benchmark is nearby and convenient, record the position of the benchmark as a point feature
3. (Optional) End and store the line feature, and start a new line feature in the same GPS file. Any time the survey is stopped there is an opportunity to store the feature to help prevent loss of data.

Component 3 - Interruption Procedure

Interruptions to the Shoreline Survey

During the survey, a variety of landforms and obstacles will be encountered. Natural landforms such as scarps or cliffs may either temporarily impede the collection of the line, cause a break in the line (where the line has to be paused and restarted after the obstacle is passed), or cause a different collection method to be used (such as walking the shoreline). The shoreline may also be physically interrupted by artificial structures (groins, jetties, seawalls). Additionally, shoreline collection may be interrupted by human obstacles (anglers, bathers). Any time the survey is interrupted (the line is stopped, a supplemental benchmark is recorded, an obstacle is avoided, or the survey deviates from the line) a note must be made on the Field Data Form or in the datalogger.

The shoreline, in some places, may be difficult to survey with a vehicle because the beach may become excessively steep, it may be very narrow, or there may be restricted access. As an example, the swash line may be at the base of a steep scarp. In this case, a notation may be "Significant scarp in the beach face. Swash line at the base of the scarp. GPS location recorded 1 meter east of scarp, on foot, beginning at point 1100 and ending at point 1700 (approximately 750 meters)". If the shoreline needs to be walked for any reason, follow this procedure:

1. While still on the shoreline, pause the data logger.
2. Make a note on the Field Data Form of the Time, Point Number, and the reason for the interruption of the line.
3. Remove the GPS antenna and datalogger from the vehicle.

4. (Optional) The logging interval may be changed to one point every five seconds
5. Position the antenna over the swash line. Vertical height above the line does not matter, only horizontal position.
6. Resume data logging.
7. Walk the shoreline, recording the swash line location.
8. Continue walking until the shoreline can be reoccupied using a vehicle.
9. Pause logging on the GPS datalogger.
10. If a benchmark is in the area, take the opportunity to survey it at this time, making notes as necessary
11. Return to the vehicle with the GPS paused, remount the GPS, reset the logging interval to one second (if necessary) and drive to the last recorded point.
12. Make a note on the Field Data Form of Time, Point Number, and make a note stating the line is being continued.
13. Resume logging; visually observe that data are being collected
14. Continue driving the shoreline.

a. Hard Structures –Physical obstacles may impede the collection of a continuous shoreline. In this case, the data logger must be paused so that only the dynamic sandy portion of the shoreline is collected. This will guarantee that the shoreline collected is comparable to other datasets and prevents the need for portions of the shoreline to be interpreted differently. If the static structure at the shoreline is collected, the feature must be coded separately or collected as a separate feature to ensure it is not misinterpreted. Make detailed and specific field notes on the data sheet to aid subsequent processing, editing, and metadata notations. If the structure causes an offset in the shoreline, such as the displacement of the shoreline on the updrift and downdrift sides of a groin (Figure 7), pause and store the line feature, go around the obstacle, and start a new line feature (in the same file) once the antenna has been repositioned over the shoreline. Anytime the GPS is removed from the vehicle there is an opportunity to add a supplemental benchmark.

Figure 7. This aerial view of GNRA-SHU demonstrates the offset of the shoreline at an interruption. Source: NPS-GATE

b. Anglers – Anglers tend to congregate near the high-tide swash line. Their fishing lines and equipment can create a hazard to a surveyor in a quad or vehicle. Also, GPS equipment can cut or break fishing lines. If anglers are encountered, there are two options.

Option 1) If there is a small group or an individual angler:

1. Pause the GPS line feature
2. Go around the obstacle
3. Reposition the antenna over the shoreline
4. Unpause the line feature
5. Verify logging
6. Resume driving the shoreline,

Option 2) If pausing the line feature is inconvenient or impossible,

1. Make a right angle (90 degree) turn landward
2. Travel inland far enough to avoid the obstruction
3. Make a right angle turn and travel past the obstacle
4. Make a pair of right angle turns and return to the shoreline.
5. Once past the obstruction, stop and make a note on either the FDF or the datalogger to alert the data processor of the deviation.

Component 4 - Completion of the Survey

Completion

After the spatial extent of the shoreline survey is completed, pause and store the line and collect the end of survey benchmark.

1. Pause and store the survey shoreline while stopped on the swash line.
2. Make a note on the Field Data Form of the End Time and ending Point Number (if making all notes on the FDF) using the format below

   FDF-**i. Start and End Times (hhmm) –** Write the time in the format shown. Use the time displayed on the GPS receiver, not off a watch. 24-hour (military) time should be used, in local standard time. For example, 0800 and 1350 for 8am and 1:50pm, local time, respectively.

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3. Store the line feature
4. Drive to the nearest or most convenient benchmark
5. Remove the GPS from the vehicle.
6. Position the GPS antenna over the final benchmark.
7. Create a new point feature
8. Once at least 12 positions have been recorded store the point feature.
9. Record the position of the final benchmark and log the information on the Field Data Form.
10. Turn off data logger

Upon return to the office, download the data and make a backup copy (SOP #7). If the data are not downloaded immediately there is a chance they could be lost due to an equipment malfunction.

Form SOP#6-1:

Field Data Form - GPS Shoreline Survey

LocationID: ____________ Observers Name: ________ Protocol/SOP Version: ____________

Survey: **GPS Shoreline** Date (mm/dd/yyyy): ________ Start Time (hhmm): ____________

End Time (hhmm): ____________

GPS System: ____________

GPS Filename: ____________

	Benchmarks				Notes	
Time	Point #	Benchmark Code	Notes (Condition, etc…)		Time	Description (Reason for notation)

Geomorphologic Monitoring Protocol for Northeast Coastal and Barrier Network

Standard Operating Procedure (SOP) # 7

Initial Post-Survey Processing

Version 1.0 (June 2005)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

Summary:

The objective of this protocol is to convert the collected shoreline position data into a useable dataset that is in the correct format and has undergone initial quality control (QA/QC) checks. Quality control checks ensure that the data collected are of the maximum quality possible. Download and QA/QC is to occur immediately following the field data collection to ensure that no data are lost due to equipment failures. In addition, prompt data processing immediately informs the surveyor if a repeat survey day is required due to equipment issues.

This protocol summarizes the data download procedures and initial quality control procedures necessary for accurate and systematic processing. It demonstrates how to connect the Trimble ProXR datalogger to a computer running Pathfinder Office, how to perform initial quality checks, and how to set up appropriate output specifications.

Connection of the datalogger to the computer for survey transfer.

Data collected in the field should be transferred to a PC for backup as soon as possible after the survey. The data should not be left in the datalogger overnight without first downloading. Even after the data are transferred, do not delete the data file until confirmed backups have been made.

1. Connect Datalogger to PC using a null modem cable ("GPS Pathfinder field data cable"), as outlined in the Trimble ProXR manual page 43 available for download at http://www.trimble.com/pathfinderproxr_ts.asp?Nav=Collection-6320
2. In Trimble Pathfinder Office opening "Select Project" Dialog, select New
   A, Project name is 4-digitPark Identifier _ Season _ 4-digit Year (e.g. ASIS_FALL_2004).
   B. The comment field will be automatically filled out with the date and time. Adjust these values to match the survey date and start time.

C. The project folder, and sub folders may be left as the default setting or changed to a custom location on the PC as appropriate.

3. Select the Utilities Menu, and choose “Data Transfer”. The software will automatically connect to the datalogger. If the software does not automatically connect, verify the connections and connection settings and select “connect”.
4. Select the file(s) to be transfer based on the date and time. Choose “add” to add the files to the transfer queue. Once all the files for the current survey have been added, select “Transfer” to transfer the files to the PC. The transferred files will be in “.ssf” format.

Differential Correction of the Shoreline Survey

The raw data downloaded in steps 1-4 of this SOP need to be differentially corrected to reach the maximum accuracy possible for the Trimble ProXR equipment. The process of differential correction compares the records received at local known station to those received in the field. The closer the reference station location is to the survey site the more accurate the differential correction.

1. After the data are transferred, choose “Differential Correction” from the Utilities menu.
2. Browse and select the recently downloaded “.ssf” file(s) generated in the previous phase.
3. Select the “Internet Search” button and choose the closest location to the survey site. This is the station data that will be used to differentially correct the data.
4. Browse to the project output folder or select the default folder.
5. Select “Smart Code and Carrier Phase Processing”
6. Select “Okay”. This will begin the differential correction of the GPS positions, and saves a file with the extension “.cor”.
7. The log file generated will be saved with the “.cor” file. It details the differential correction process and any errors that have occurred. If some points remain uncorrected (less than 100% code correction), try processing with an alternate station by repeating steps 1-6. If a few occasional points remain uncorrected delete them in the QA/QC stage below. If a large contiguous block of points is uncorrected, that section of the shoreline may have to be resurveyed on the following day. Typically 100% of the points will be corrected.

Initial QA/QC

QA/QC (Quality Assurance/Quality Control) is a verification step that ensures the data collected have had obvious errors removed and that the remaining data likely accurately represent the shoreline. Verification of the three (or more) known benchmarks embedded in the survey adds further and credence to the collected shoreline positions.

1. Choose “Open” from the File menu.

2. Browse to and select the “.cor” file generated in Differential Correction steps. Select Open. This will bring up a visual display of the points collected.

3. During this procedure the surveyor should be present, along with the notes on the Field Data Form. Visually compare the expected point locations with the recorded point locations. If any points are obvious errors they should be deleted by clicking on the point, and choosing "Delete Feature" from the Edit menu. Occasional points that remained uncorrected should be deleted at this time.

4. Compare the known benchmarks collected with their known values. To display benchmark positions, select the point with the arrow tool. Then select "Position attributes" from the Data menu. Compare the latitude and longitude of the position with the latitude and longitude of the known benchmark location from its datasheet. If the difference between the recorded position and its known value is greater than one meter the shoreline may need to be re-surveyed.

Data Export

Once the data have been downloaded, differentially corrected, and passed through initial QA/QC, they should be backed up. Making duplicate copies of the data should be a standard practice to prevent problems associated with loss of files and possible data corruption.

1. With the ".cor" file open, choose "Export" under the Utilities menu.
2. Choose an output folder or select the default folder.
3. Choose "Sample ArcView Shapefile Setup" from the drop-down menu.
4. Select "Change Setup Options" and choose the following settings from each of the tabs:
    a. Select Properties
        i. Data
            1. Features – Positions and Attributes – selected
                a. Export all Features
            2. Notes – checked
            3. Velocity Records – unchecked
            4. Sensor Records - unchecked
        ii. Output
            1. Select "Combine all input files and output to the project export folder"
            2. Select DOS files
        iii. Attributes – Export Menu Attributes As – Select "Attribute Value"
            1. All Feature Types – select ONLY
                a. PDOP
                b. Date Recorded
                c. Time Recorded
            2. Point Features – select ONLY
                a. Position
                b. Horizontal Precision
            3. Line Features – select ONLY
                a. Length (2d)
                b. Avg Horizontal Precision
            4. Area Features – select NONE

- iv. Units –
  1. Use Export Units – select:
     a. Meters
     b. Square Meters
     c. Meters per second
  2. Decimal Places
     a. Lat/Long – 9
     b. North/east – 3
     c. Height – 3
     d. Distance – 3
     e. Area – 3
     f. Velocity – 3
     g. Precision – 1
     h. Time - 0
- v. Position Filter – Select Filter by GPS Position Info
  1. Minimum Satellites – 2D (three or more SVs)
  2. Maximum PDOP (any)
  3. Maximum HDOP (any)
  4. Include positions that are – select ONLY
     a. Realtime Differential
     b. Differential
     c. RTK (fixed)
     d. Phase Processed (fixed)
- vi. Coordinate System – UTM 18 North/19 North (CACO Only)
- vii. Arcview Shapefile – select NONE

5. As an alternate to step 4, choose "New Setup" and use the above settings. This option will allow the user to save a template for export settings.
6. Select "Okay" and the data will be exported, along with a text log file.
7. Copy the exported data, along with the original ".ssf", the initial ".cor", any supporting text log files, and an image scan of the Field Data Form, to an external media (CD or floppy) so that there are separate backup locations, one on the hard disk drive and one on the removable media. Place all files in a folder labeled with the survey location and time.

Once the data have been exported and backed up, verify that the backups exist in various locations, including the PC and a least one type of removable media. This guarantees that duplicate copies of the raw and corrected files exist. Once the duplicate copies are verified the data may be deleted from the datalogger, and data analysis may begin.